User Manual
SONO-SILO

SONO-SILO$_{Standard}$ in Stainless Steel Design

SONO-SILO$_{Xtrem}$ for Intensive Mixer

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User Manual for SONO-SILO

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Thank you for buying an IMKO moisture probe.

Please carefully read these instructions in order to achieve ideal results with your probe SONO-SILO for the in-line moisture measurement. Should you have any questions or suggestions regarding your new probe after reading, please do not hesitate to contact our authorised dealers or IMKO directly. We will gladly help you.

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1. Instrument Description SONO-SILO

1.1.1. The patented TRIME® TDR-Measuring Method

The TDR technology (**T**ime-**D**omain-**R**eflectometry) is a radar-based dielectric measuring procedure at which the transit times of electromagnetic pulses for the measurement of dielectric constants, respectively the moisture content are determined. SONO-SILOConcrete consists of a high grade hardened casing with a wear-resistant sensor head with ceramic window. The SONO-SILOPTFE probe head is made of PTFE and thus providing best possible anti adhesive properties.
An integrated TRIME TDR measuring transducer is installed into the casing. A high frequency TDR pulse (1GHz), passes along wave guides and generates an electro-magnetic field around these guides and herewith also in the material surrounding the probe. Using a new patented measuring method, IMKO has achieved to measure the transit time of this pulse with a resolution of one picosecond ($1x10^{-12}$), consequently determine the moisture and the conductivity of the measured material.

The established moisture content, as well as the conductivity, respectively the temperature, can either be uploaded directly into a SPC via two analogue outputs 0(4) ...20 mA or recalled via a serial RS485 interface.

1.1.2. TRIME® compared to other Measuring Methods

In contrary to conventional capacitive or microwave measuring methods, the TRIME® technology (**T**ime-Domain-**R**eflectometry with **I**ntelligent **M**icromodule **E**lements) does not only enable the measuring of the moisture but also to verify if the mineral concentration specified in a recipe has been complied with. This means more reliability at the production.

TRIME-TDR technology operates in the ideal frequency range between 600MHz and 1,2 GHz. Capacitive measuring methods (also referred to as Frequency-Domain-Technology) , depending on the device, operate within a frequency range between 5MHz and 40MHz and are therefore prone to interference due to disturbance such as the temperature and the mineral contents of the measured material. Microwave measuring systems operate with high frequencies >2GHz. At these frequencies, nonlinearities are generated which require very complex compensation. For this reason, microwave measuring methods are more sensitive in regard to temperature variation.

SONO probes calibrate themselves in the event of abrasion due to a novel and innovative probe design. This consequently means longer maintenance intervals and, at the same time, more precise measurement values.

The modular TRIME technology enables a manifold of special applications without much effort due to the fact that it can be variably adjusted to many applications.

1.1.3. Areas of Application for the SONO-SILO Probes

The SONO-SILO probe is suited for installation into containers, hoppers, silos, dryers and mixers.

- The SONO-SILOStandard is suited for measuring of abrasive materials. The probe head consists of stainless steel with a rectangular ceramic window.
- The SONO-SILOXtrem is suited for measuring moisture of fresh concrete in intensive mixers. The probe head has rectangular window with high abrasion resist Si3O4 ceramic.

1.2. Mode of Operation

1.2.1. Measurement value collection with pre-check, average value and filtering

SONO probes measure internally at very high cycle rates of 10 kHz and update the measurement value at a cycle time of 250 milliseconds at the analogue output. In these 250 milliseconds a probe-internal pre-check of the moisture values is already carried out, i.e. only plausible and physically checked and pre-averaged single measurement values are be used for the further data processing. This increases the reliability for the recording of the measured values to a downstream control system significantly.
In the **Measurement Mode CS** (Cyclic-Successive), an average value is not accumulated and the cycle time here is also 200 milliseconds. In the **Measurement Mode CA, CF and CK**, not the momentarily measured individual values are directly issued, but the floating average value is accumulated via a variable number of measurements in order to filter out temporary variations. These variations can be caused by inhomogeneous moisture distribution in the material surrounding the sensor head. The delivery scope of SONO-SILO includes suited parameters for the averaging period and a universally applicable filter function deployable for currently usual applications. The time for the average value accumulation, as well as various filter functions, can be adjusted for special applications.

1.2.2. Determination of the mineral Concentration

With the radar-based TRIME measurement method, it is now possible for the first time, not only to measure the moisture, but also to provide information regarding the conductivity, respectively the mineral concentration or the composition of a special material. Hereby, the attenuation of the radar pulse in the measured volume fraction of the material is determined. This novel and innovative measurement delivers a radar-based conductance value (RbC – **R**adar-**b**ased-**C**onductivity) in dS/m as characteristic value which is determined in dependency of the mineral concentration and is issued as an unscaled value. The RbC-measurement range of the SONO-SILO is 0..12dS/m

1.2.3. Temperature Measurement

A temperature sensor is installed into the SONO-SILO which establishes the casing temperature beneath the electronic housing (see point 2.2). The temperature can optionally be issued at the analogue output 2. As the TRIME electronics operates with a power of approximately 1.5 W, the probe casing does slightly heat up. A very precise measurement of the material temperature is therefore only possible to a certain degree and only when the electronic housing is completely is completely surrounded by the material. The material temperature can be determined after an external calibration and compensation of the sensor self-heating.

1.2.4. Analogue Outputs

The measurement values are issued as a current signal via the analogue output. With the help of the service program **SONO-CONFIG,** the SONO-SILO can be set to the two versions for 0..20mA or 4..20mA. Furthermore, it is also possible to variably adjust the moisture dynamic range e.g. to 0-10%, **0-20%** or 0-30% or any other range. For a 0-10V DC voltage output, a 500R resistor can be installed in order to reach a 0..10V output.

Analogue Output 1: Moisture in % (0…20%, variable adjustable)
Analogue Output 2: Conductivity (RbC) or optionally the temperature.
In addition, there is also the option to split the analogue output 2 into two ranges: into 4..11mA for the temperature and 12..20mA for the conductivity. The analogue output 2 hereby changes over into an adjustable one-second cycle between these two (current) measurement windows.

For the analogue outputs 1 and 2 there are thus two adjustable options:
Analog Output: (two possible selections)

0..20mA **4..20mA**

Output Channel 1 and 2: (three possible selections)

1. **Moist, Temp.** Analogue output 1 for moisture, output 2 for temperature.
   or
2. **Moist, Conductivity** Analogue output 1 for moisture, output 2 for conductivity in a range of 0..20dS/m.
   or
3. **Moist, Temp/Conductivity** Analogue output 1 for moisture, output 2 for both, temperature and conductivity with an automatic current-window change.

For analogue output 1 and 2 the moisture dynamic range and temperature dynamic range can be variably adjusted. The moisture dynamic range should not exceed 100%

Moisture Range:
Maximum: e.g. 20 for sand (Set in %)
Minimum: 0

Temp. Range:
Maximum: 70 °C
Minimum: 0 °C

1.2.5. The serial RS485 interface

SONO-SILO is equipped with a standard RS485 interface to serially readout individual parameters or measurement values. An easy to implement data transfer protocol enables the connection of several sensors/probes at the RS485-Interface. In addition, the SONO-SILO can be directly connected to the USB port of a PC, in order to adjust individual measuring parameters or conduct calibrations, via the RS485 USB Module which can be provided by IMKO.

1.2.6. Error Reports and Error Messages

SONO-SILO is very fault-tolerant. This enables failure-free operation. Error messages can be recalled via the serial RS485 interface.

2. Configuration of the Measure Mode

The configuration of SONO-SILO is preset in the factory before delivery. A process-related later optimisation of this device-internal setting is possible with the help of the service program **SONO-CONFIG**. For all activities regarding parameter setting and calibration the probe can be directly connected via the RS485 interface to the PC via a RS485 USB-Module which is available from IMKO.

The following settings of SONO-SILO can be amended with the service program **SONO-CONFIG**:

Measurement-Mode and Parameters:

- Measurement Mode A-On-Request (only in network operation for the retrieval of measurement values via the RS485 interface).
- Measurement Mode C Cyclic:
  Setting CA: (Cyclic-Average) For relative short measuring processes with continual average value, filtering and an accuracy of up to 0.1%
  Setting CF: (Cyclic-Float-Average) For very slow measuring processes with floating average value, filtering and an accuracy of up to 0.1%
  Setting CS: (Cyclic-Successive) For very short measuring processes without floating average with internal up to 100 measurements per second and a cycle time of 200 milliseconds at the analogue output.
  Mode CC: (Cyclic Cumulated) with automatic summation of a moisture quantity during one batch process.
  Mode CH: (Cyclic Hold) similar to mode CC but without summation.

- Average Time (reaction rate of the measurement values)
- Calibration (if completely different materials are deployed)
- Filter Function

Each of these settings will be preserved after shut down of the probe and is therefore stored on a permanent basis.

2.1. Operation Mode CA and CF at non-continuous Material Flow

For mode CA and CF the SONO probes are supplied ex factory with suited parameters for the averaging time and with a universally deployable filter function suited for most currently applications.

The setting options and special functions of SONO probes depicted in this chapter are only rarely required. It is necessary to take into consideration that the modification of the settings or the realisation of these special functions may lead to faulty operation of the probe!

For applications with non-continuous material flow, there is the option to optimise the control of the measurement process via the adjustable filter values *Filter-Lower-Limit, Filter-Upper-Limit* and the time constant *No-Material-Keep-Time*. The continual/floating averaging can be set with the parameter *Average-Time*.

Filter Parameter in the Measurement Mode CA and CF	***Function***
Average-Time (***Continual/Floating Average Value)***	The time (in seconds) for the generation of the continual/floating average value can be set with

Standard Setting: **3** *Setting Range: 2…20*	this parameter.
Filter-Upper-Limit Standard Setting: **3** *Setting Range: 1.1…..5*	Too high measurement values generated due to metal wipers or blades are filtered out. The upper limit is set in %. For a moisture value (reading) of e.g. 8% the upper limit is thus 8 + 3 = 11%
Upper-Limit-Keep-Time Standard Setting: **4** *Setting Range: 2...10*	The maximum duration (in seconds) of the filter function for Upper-Limit-failures (too high measurement values) can be set with this parameter.
Filter-Lower-Limit Standard Setting: **0.90** *Setting Range: 0.8….0.97*	Too low measurement values generated due to insufficient material at the probe head, e.g. due to the mixer blades, are filtered out. The lower limit is set as a multiplication factor. For a moisture value (reading) of e.g. 8% the lower limit is thus 8 x 0.9 = 7.2%
Lower-Limit-Keep-Time Standard Setting: **4** *Setting Range: 2...20*	The maximum duration (in seconds) of the filter function for Lower-Limit-failures (too less material at the probe) can be set with this parameter.
Kalman Filter-Parameter in Measurement Mode CK:	
Q-Parameter ***Standard Setting: 1x10-5*** ***Setting Range: 0.01…1x10-7***	This Kalman filter parameter Q is used to characterize the systemic measurement error. It is recommended to leave this parameter to the default setting!
R-Parameter ***Standard Setting: 0.033*** ***Setting Range: 0.01 ….. 0.1***	This Kalman filter parameter R is used for smoothing the measurement error. The lower this parameter, the faster is the response to smaller changes in the moisture readings. The higher this parameter is the more smoothed the measured value, but with a delayed reaction time. It is recommended to leave this parameter to the default setting!
K-Parameter ***Standard Setting: 0.01*** ***Setting Range: 0.01 ….. 0.2***	This special Kalman filter parameter K is used for a pre-dynamic behaviour of the Kalman Filter for higher changes in the moisture reading, i.e. the reaction rate of the measurement signal can be affected hereby. The K-parameter is related to the Average-Time. It is recommended to leave this parameter to the default setting!

2.1.1. *Average Time* in the measurement mode CA and CF

SONO-SILO establishes every 200 milliseconds a new single measurement value which is incorporated into the continual averaging and issues the respective average value in this timing cycle at the analogue output. The averaging time therefore accords to the “memory” of the SONO-SILO. The longer this time is selected, the more inert is the reaction rate, if differently moist material passes the probe. A longer averaging time results in a more stable measurement value. This should in particular

be taken into consideration, if the SONO-SILO is deployed in different applications in order to compensate measurement value variations due to differently moist materials.

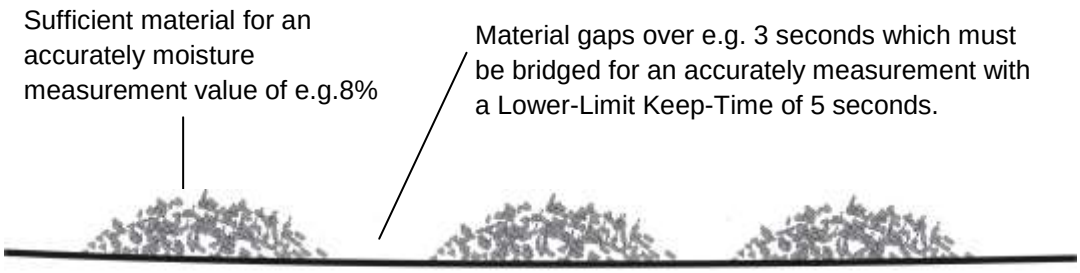
At the point of time of delivery, the *Average Time* is set to 4 seconds. This value has proven itself to be useful for many types of applications. At applications which require a faster reaction rate, a smaller value can be set. Should the display be too “unstable”, it is recommended to select a higher value.

The *Average Time* can be adjusted with the service program **SONO-CONFIG**.

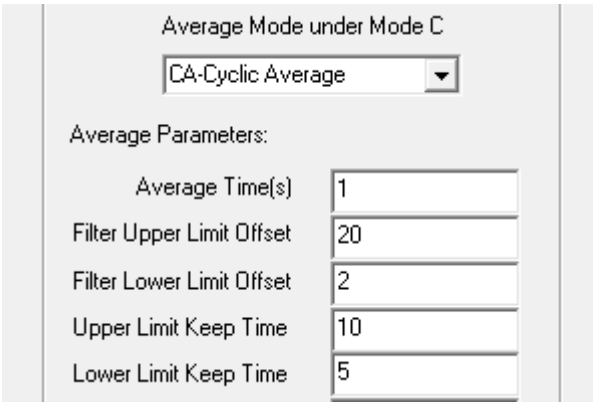
2.1.2. Filtering at material gaps in mode CA or CF

A SONO probe is able to identify, if temporarily no or less material is at the probe head and can filter out such inaccurate measurement values **(*Filter-Lower-Limit)***. Particular attention should be directed at those time periods in which the measurement area of the probe is only partially filled with material for a longer time, i.e. the material (sand) temporarily no longer completely covers the probe head. During these periods (***Lower-Limit-Keep-Time****)*, the probe would establish a value that is too low. The ***Lower-Limit-Keep-Time*** sets the maximum possible time where the probe could determine inaccurate (too low) measurement values.
Furthermore, the passing or wiping of the probe head with metal blades or wipers can lead to the establishment of too high measurement values (***Filter-Upper-Limit)***. The ***Upper-Limit-Keep-Time*** sets the maximum possible time where the probe would determine inaccurate (too high) measurement values.
Using a complex algorithm, SONO probes are able to filter out such faulty individual measurement values. The standard settings in the **Measurement Mode CA and CF** for the filter functions depicted in the following have proven themselves to be useful for many applications and should only be altered for special applications.

It is appropriate to bridge material gaps in mode CA with Upper- and Lower-Limit Offsets and Keep-Time. For example the Lower-Limit Offset could be adjusted with 2% with a Lower-Limit Keep-Time of 5 seconds. If the SONO probe determines a moisture value which is 2% below the average moisture value with e.g. 8%, than the average moisture value will be frozen at this value during the Lower-Limit Keep-Time of 5 seconds. In this way the material gap can be bridged. This powerful function inside the SONO probe works here as a highpass filter where the higher moisture values are used for building an average value, and the lower or zero values are filtered out. In the following this function is described with SONO parameters.


Sufficient material for an accurately moisture measurement value of e.g.8%
Material gaps over e.g. 3 seconds which must be bridged for an accurately measurement with a Lower-Limit Keep-Time of 5 seconds.

The following parameter setting in mode CA fits a high pass filtering for bridging material gaps.



The Filter Upper-Limit is here deactivated with a value of 20, the Filter Lower-Limit is set to 2%. With a Lower-Limit Keep-Time of 5 seconds the average value will be frozen for 5 seconds if a single measurement value is below the limit of 2% of the average value. After 5 seconds the average value is deleted and a new average value building starts. The Keep-Time function stops if a single measurement value lies within the Limit values.

2.1.3. Mode CC – automatic summation of a moisture quantity during one batch process

Simple PLCs are often unable to record moisture measurement values during one batch process with averaging and data storage. Furthermore there are applications without a PLC, where accumulated moisture values of one batch process should be displayed for a longer time to the operating staff. Previously available microwave moisture probes on the market show three disadvantages:

1. Such microwave probes need a switching signal from a PLC. This increases the cabling effort.
2. Time delays can occur during the summation time with a trigger signal. This is particularly disadvantageous for small batches. Recipe errors can occur.
3. Material gaps during one batch process will lead to zero measurement values which falsify the accumulated measurement value considerably. Recipe errors can occur.

Unlike current microwave probes, SONO probes work in mode CC with automatic summation, where it is really ensured that material has contact with the probe. This increases the reliability for the moisture measurement during one complete batch process. The summation is only working if material fits at the probe. Due to precise moisture measurement also in the lower moisture range, SONO probes can record, accumulate and store moisture values during a complete batch process without an external switching or trigger signal. The SONO probe “freezes” the analogue signal as long as a new batch process starts. So the PLC has time enough to read in the “freezed” moisture value of the batch. For applications without a PLC the “freezed” signal of the SONO probe can be used for displaying the moisture value to a simple 7-segment unit as long as a new batch process starts.

With the parameter **Moisture Threshold** the SONO probe can be configured to the start moisture level where the summation starts automatically. Due to an automatic recalibration of SONO probes, it is ensured that the zero point will be precisely controlled. The start level could be variably set dependent to the plant. Recommended is a level with e.g. 0.5% to 1%.

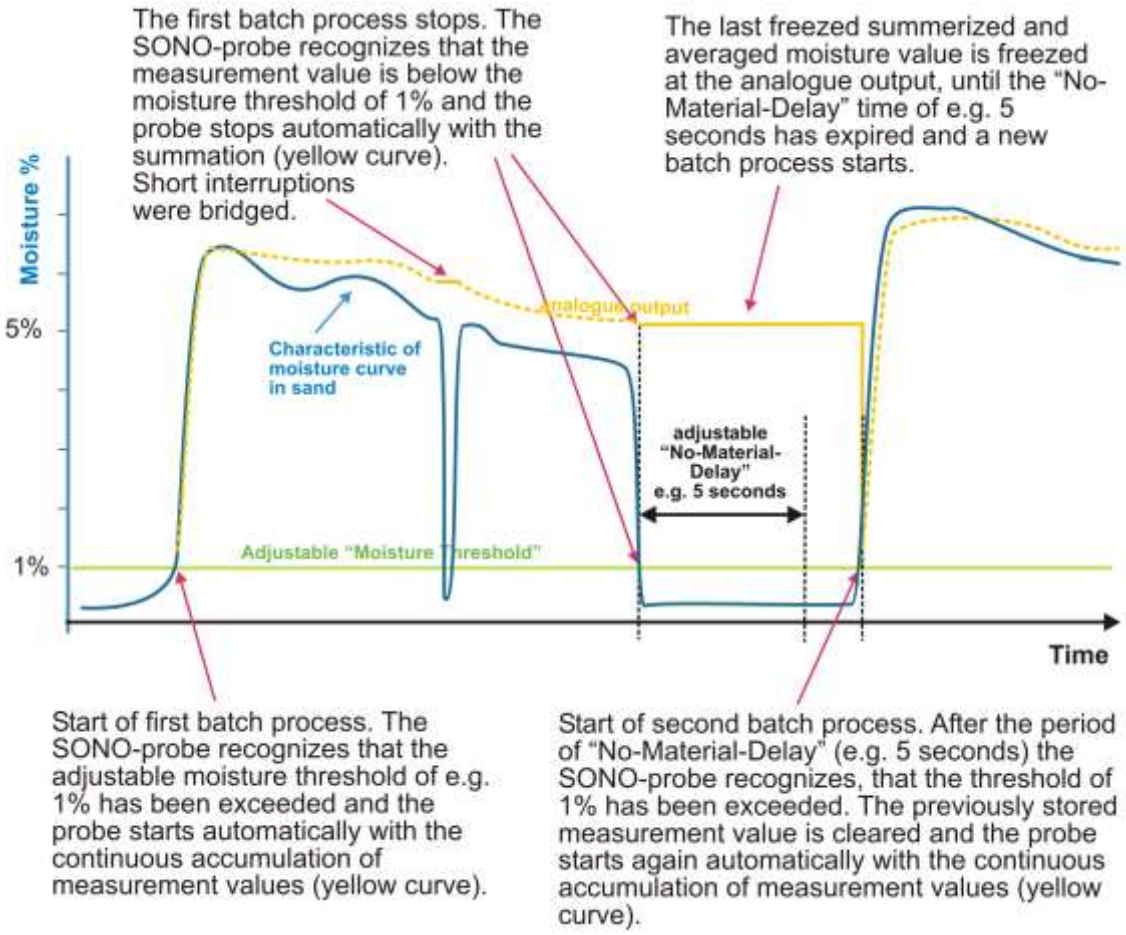
With the parameter **No-Material-Delay** a time range can be set, where the SONO probe is again ready to start a new batch process. Are there short material gaps during a batch process which are shorter than the “No-Material-Delay”, with no material at the probes surface, then the SONO probe pauses shortly with the summation. Is the pause greater as the “No-Material-Delay” then the probe is ready to start a new batch process.

How can the mode CC be used, if the SONO probe cannot detect the „moisture threshold“ by itself, e.g. if there is constantly material above the probe over a longer time: In this case, a short interrupt of the probe´s power supply, e.g for about 0.5 seconds with the help of a relay contact of the PLC, can restart the SONO probe at the beginning of the material transport. After this short interrupt the SONO probe starts immediately with the summarizing and averaging.

Please note: It should be noted that no material sticks on the probes surface. Otherwise the moisture zero point of the probe will be shifted up and the probe would not be detect a moisture low value below the “Moisture-Threshold”.

Following possible parameter settings in mode CC inside the SONO probe can be set:

Parameter in mode CC	***Function***
Moisture Threshold (in %-moisture) Standard Setting: 1 *Setting Range: 1….20*	The accumulation of moisture values starts above the „Moisture Threshold“ and the analogue signal is output. The accumulation pauses if the moisture level is below the threshold value.
No-Material-Delay (in seconds) Standard Setting: 5 *Setting Range: 1….20*	The accumulation stopps if the moisture value is below the moisture threshold. The SONO probes starts again in a new batch with a new accumulation after the time span of the “No-Material-Delay” is exceeded.


The first batch process stops. The SONO-probe recognizes that the measurement value is below the moisture threshold of 1% and the probe stops automatically with the summation (yellow curve). Short interruptions were bridged.
The last freezed summerized and averaged moisture value is freezed at the analogue output, until the “No-Material-Delay” time of e.g. 5 seconds has expired and a new batch process starts.
Moisture %
5%
1%
Characteristic of moisture curve in sand
analogue output
adjustable “No-Material-Delay” e.g. 5 seconds
Adjustable “Moisture Threshold”
Time
Start of first batch process. The SONO-probe recognizes that the adjustable moisture threshold of e.g. 1% has been exceeded and the probe starts automatically with the continuous accumulation of measurement values (yellow curve).
Start of second batch process. After the period of “No-Material-Delay” (e.g. 5 seconds) the SONO-probe recognizes, that the threshold of 1% has been exceeded. The previously stored measurement value is cleared and the probe starts again automatically with the continuous accumulation of measurement values (yellow curve).

2.1.4. Mode CH – Automatic Moisture Measurement in one Batch

If the PLC already accumulates moisture values, than an additional automatic summation of a moisture quantity inside the SONO-VARIO during one batch process will produce errors.

From the procedure the mode CH is identically with the mode CC, but without automatic summation.

2.2. Overview of single modes for different applications

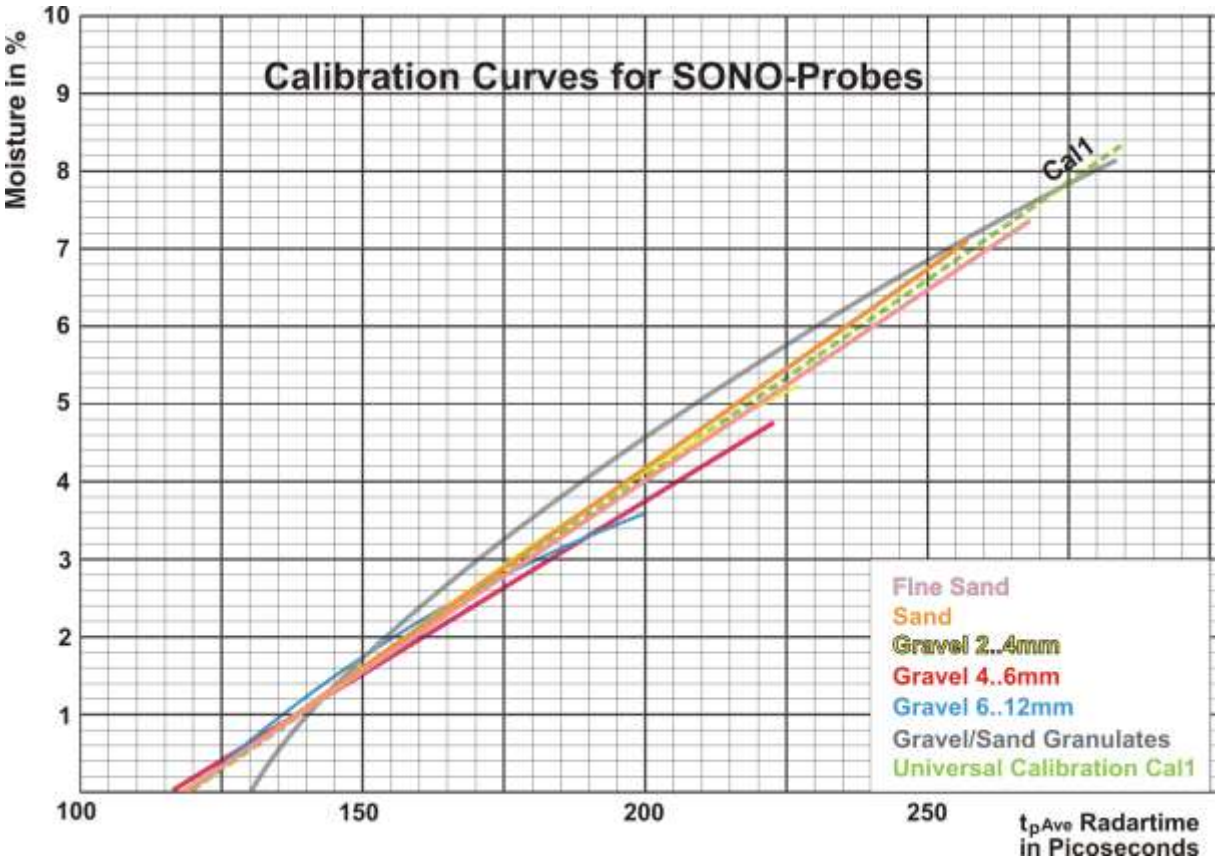
The following table gives an overview about possible parameter settings in different modes:

Application/ Installation and specific Parameters	**Sand/ Gravel under a silo flap**	**Above a conveyor belt**	**Inside a mixer**	**Inside a fluid bed dryer**	**Gene-rally simple appli-cations**	**in a screw conveyor with filtering options due to metal spiral**	**At the end of a screw conveyor Long term process**
Operating Mode	CH	CH	CK	CK	CA	CK	CF
Average-Time	2	2	5	5	10	10	30
Filter-Upper-Limit Offset	inactiv 100	inactiv 100	inactiv 100	inactiv 100	e.g. 20	inactiv 100	e.g. 20
Filter-Lower-Limit Offset	inactiv 100	inactiv 100	inactiv 100	inactiv 100	e.g. 10	inactiv 100	e.g. 5
Upper-Limit-Keep-Time	inactiv 10	inactiv 10	inactiv 10	inactiv 10	e.g. 10	inactiv 10	e.g. 10
Lower-Limit-Keep-Time	inactiv 10	inactiv 10	inactiv 10	inactiv 10	e.g. 10	inactiv 10	e.g. 10
Moisture Threshold	0.1	0.1	0.1	0.1	-	0.1	-
No-Material-Delay	10	10	10	10	-	inactiv	-
Boost	35	35	20	20	-	20	-
Offset	0.5	0.5	1	1	-	1	-
Weight	5	5	25	25	-	50	-
Invalid Measure Count	2	2	inactiv	inactiv	-	inactiv	-

For very difficult applications, where it is not certain, which mode is the best, we recommend to select mode CA with averaging time = 1 second. With help of the software SONO-CONFIG a data record can be stored directly during process conditions. After forwarding this data set to IMKO, we would be pleased to be at your disposal for finding the best suitable working mode.

2.3. SONO-SILO for measuring Moisture of Sand and Aggregates

The TRIME-TDR technology with the radar method offers high reliability for measuring moisture of sand and aggregates. Conventional measurement techniques such as microwave technology show considerable dependencies in different grading ranges.
The calibration curve Cal1 "Universal Sand/Gravel/Grit" of a SONO probe is suitable for measuring the moisture in sand with a grading size of 0-2mm, as well as in gravel and grit.



Fine Sand

Sand

Gravel 2..4mm

Gravel 4..6mm

Gravel 6..12mm

Gravel/Sand Granulates

2.3.1. SONO-SILO in use with different sand grading ranges

The sand densitiy is varying depending on grading ranges but also on minerals type. The SONO-SILO as standard version is calibrated with calibration curve Cal1 for sand with a grading range of 0-2mm. With Cal1 it is also possible to measure gravel and grit. Depending on grading ranges the bulk density of sand is varying considerably. Therefore for other grading ranges up to 0-8mm there are other **calibration curves Cal1 to Cal6** stored inside the SONO-SILO.

Following table gives an overview about the calibration curves inside the SONO-SILO for sand, gravel and grit:

Aggregates and grading range	**Bulk Density** Please note: the bulk density may vary dependent on type of plant.	**Recommended Calibration Curve**
Sand 0-2mm,	D= c. 1,5	**Cal1: Universal sand, gravel and grit**
Gravel and grit 4 to 32mm	D= c. 1,7	Cal6: gravel and grit (similar to Cal1)
Sand 0-2mm	D= c. 1,6	Cal2, 1.6 for bulk density 1.6
Sand/Gravel 0-4mm	D= c. 1,7	Cal3, 1.7 for bulk density 1.7
Sand/Gravel 0-5mm	D= c. 1,8	Cal4, 1.8 for bulk density 1.8
Sand/Gravel 0-8mm	D= c. 1,9	Cal5, 1.9 for bulk density 1.9

Where very high demands are made in recipe accuracies, e.g. +-1 liter per m^3, it is recommended to make a fine adjustment, ideally inside the PLC.

How is it possible to avoid a change of the calibration curve inside the SONO-SILO for different grading ranges?

If it is necessary to measure different sand grading ranges with only one SONO-SILO, without an online changing of the calibration curve, than a measurement value conversion can be done inside the PLC with the knowing grading range. Furthermore it could be of advantage if a SONO probe must be not adapted to a fixed grading range (making replacement parts easier to keep in stock).

Following table gives an overview about sand grading ranges, bulk density and the analog output of the SONO-SILO. With a little math it is possible to translate a standard moisture measurement value measured with in Cal1, into the correct measurement value associated to the grading range.

4-20mA Current output: Measurement conversion for 0 to 20% moisture at different grading ranges with standard calibration curve Cal1:

Grading range and bulk density in kg/dm³	Moisture value at 4mA current at the analog output (theoretically)	A value of 0% moisture thus conforms to an output current in mA at the analog output of:	Moisture value at 20mA output current at the analog output:
0-2mm 1.5	0.00%	4mA	20%
0-2mm 1.6	-0.29%	4.24mA	18.4%
0-4mm 1.7	-0.55%	4.48mA	17.1%
0-5mm 1.8	-0.78%	4.72mA	15.9%
0-8mm 1.9	-0.98%	4.96mA	14.8%
2.0	-1.16%	5.2mA	13.8%
2.1	-1.33%	5.44mA	12.9%

0-20mA Current output: Measurement conversion for 0 to 20% moisture at different grading ranges with standard calibration curve Cal1:

Grading range and bulk density in kg/dm³	Moisture value at 4mA current at the analog output (theoretically)	A value of 0% moisture thus conforms to an output current in mA at the analog output of:	Moisture value at 20mA output current at the analog output:
0-2mm 1.5	0.00%	0mA	20%
0-2mm 1.6	-0.29%	0.3mA	18.4%
0-4mm 1.7	-0.55%	0.6mA	17.1%
0-5mm 1.8	-0.78%	0.9mA	15.9%
0-8mm 1.9	-0.98%	1.2mA	14.8%
2.0	-1.16%	1.5mA	13.8%
2.1	-1.33%	1.8mA	12.9%

Please note: The guide values only apply for sand. For measuring gravel and grit with different gradings, it is recommend to use the standard calibration curve Cal1.
I.e. 0(4)-20mA corresponds to 0-20% moisture.

3. Calibration Curves

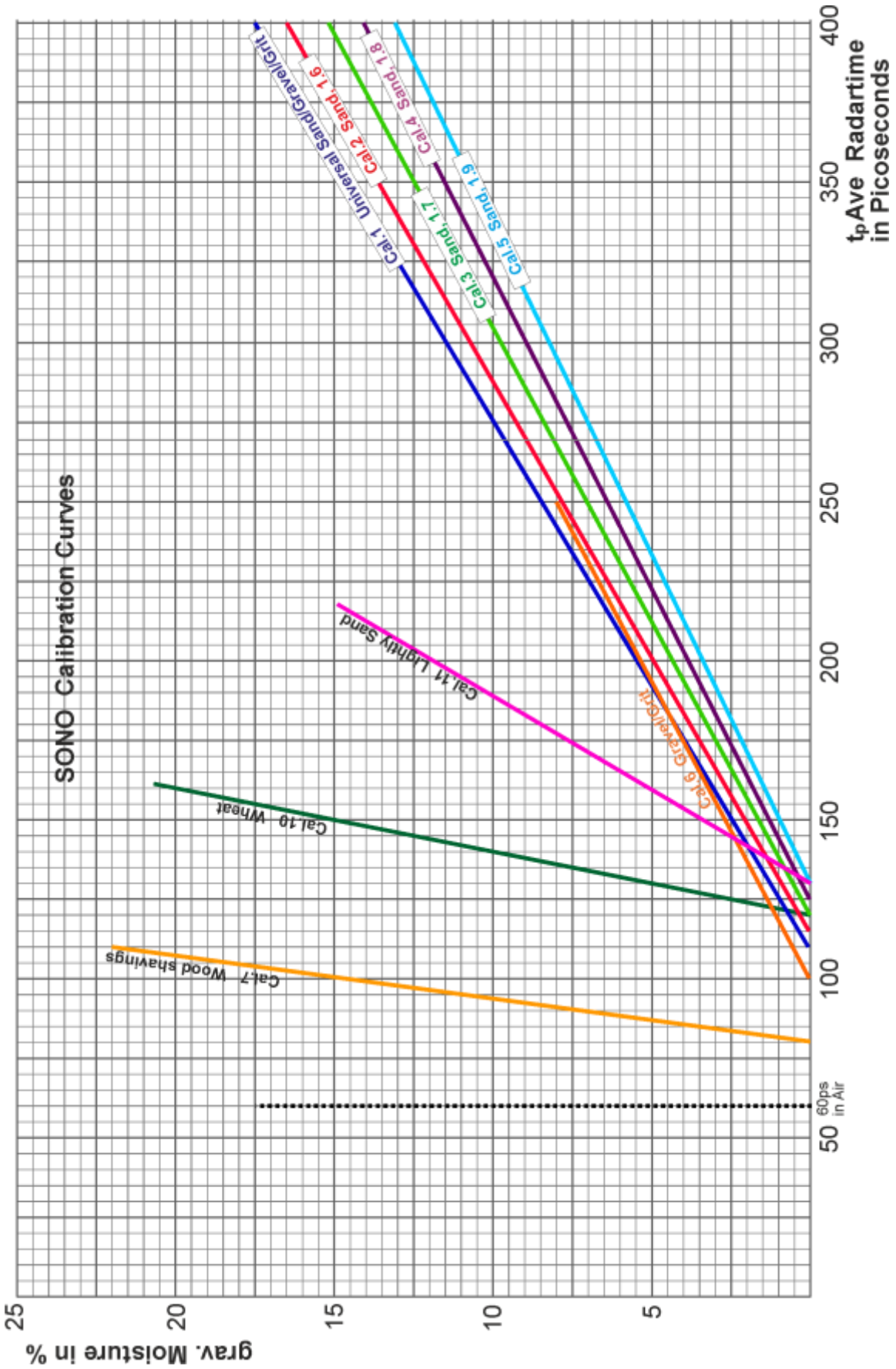
SONO-SILO is supplied with a universal calibration curve for sand (Cal1: Universal Sand/Gravel/Grit). A maximum of 15 different calibration curves (CAL1 ... Cal15) are stored inside the SONO probe and can optionally be activated via the program **SONO-CONFIG**.

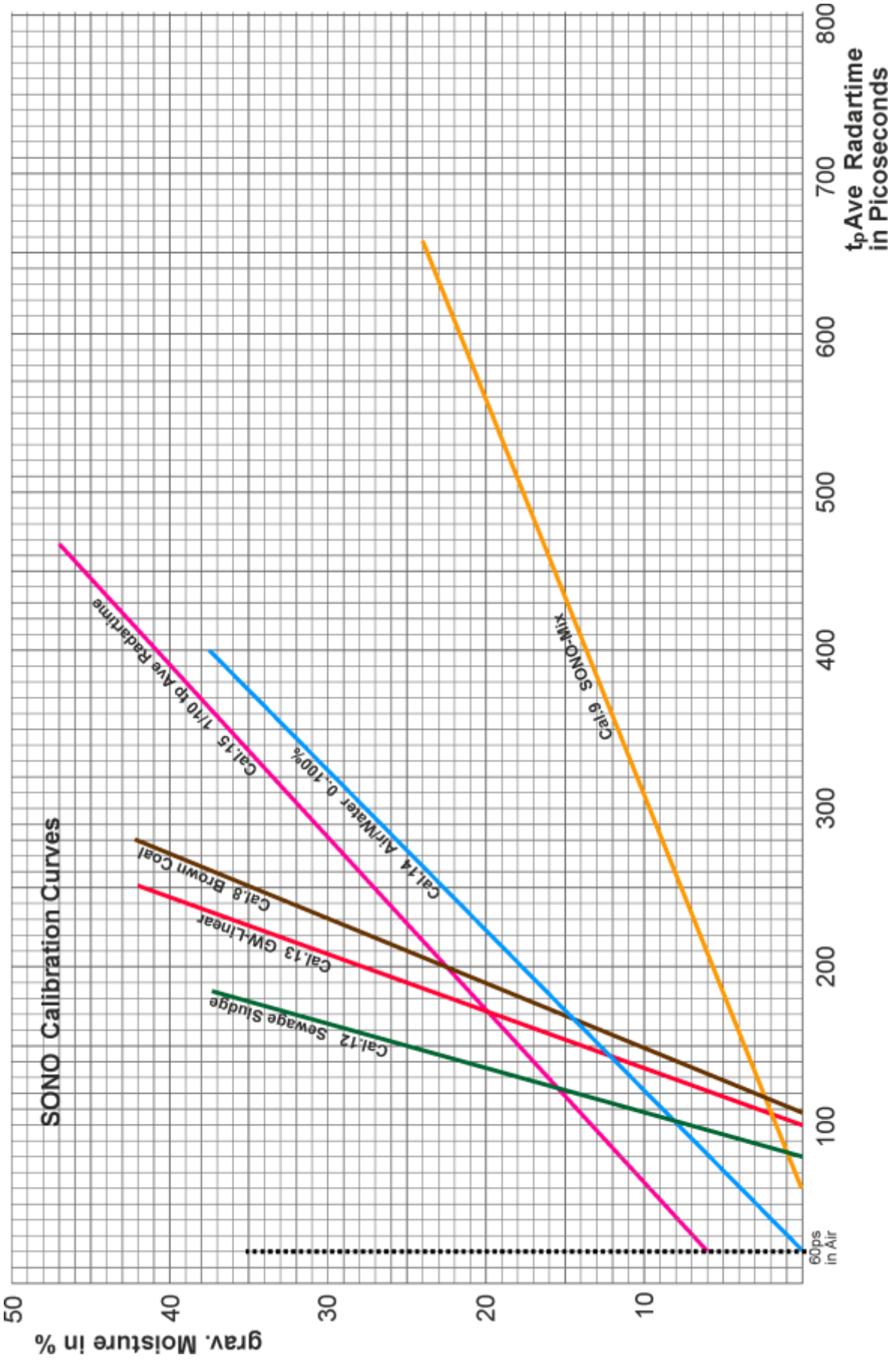
A preliminary test of an appropriate calibration curve (Cal1. .15) can be activated in the menu **"Calibration"** and in the window **"Material Property Calibration"** by selecting the desired calibration curve (Cal1...Cal15) and with using the button "**Set Active Calib**". The finally desired and possibly altered calibration curve (Cal1. .15) which is activated after switching on the probes power supply will be adjusted with the button "**Set Default Calib**".

Nonlinear calibrations are possible with polynomials up to 5th grade (coefficients m0...m5).

IMKO offers more suitable calibration coefficients for different materials. These calibration coefficients can be entered and stored in the SONO probe by hand with the help of SONO-CONFIG.

The charts (Cal.1 .. 15) in the next two pages show different selectable calibration curves which are stored inside the SONO probe.
Plotted is on the y-axis the gravimetric moisture (**MoistAve**) and on the x-axis depending on the calibration curve the associated radar time **tpAve** in picoseconds. With the software **SONO-CONFIG** the radar time **tpAve** is shown on the screen parallel to the moisture value **MoistAve** (see "Quick Guide for the Software SONO-CONFIG). In air, SONO-probes measure typically 60 picoseconds radar time.


SONO Calibration Curves
gray. Moisture in %
25
20
15
10
5
tpAve Radartime in Picoseconds
400
350
300
250
200
150
100
50
60ps in Air
Cal.1 Universal Sand/Gravel/Grit
Cal.2 Sand, 1.6
Cal.4 Sand, 1.8
Cal.5 Sand, 1.9
Cal.3 Sand, 1.7
Cal.11 Lightly Sand
Cal.6 Gravel/Grit
Cal.10 Wheat
Cal.7 Wood shavings


SONO Calibration Curves
grav. Moisture in %
50
40
30
20
10
800
700
600
500
400
300
200
100
tpAve Radartime in Picoseconds
60ps in Air
Cal.9 SONO-Mix
Cal.14 Air/Water 0..100%
Cal.15 1/10 sp Ave Radartime
Cal.8 Brown Coal
Cal.13 GW-Linear
Cal.12 Sewage Sludge

3.1.1. Creating a linear Calibration Curve for a specific Material

The calibration curves Cal1 to Cal15 can be easily created or adapted for specific materials with the help of SONO-CONFIG. Therefore, two measurement points need to be identified with the probe. Point P1 at dried material and point P2 at moist material where the points P1 and P2 should be far enough apart to get a best possible calibration curve. The moisture content of the material at point P1 and P2 can be determined with laboratory measurement methods (oven drying). It is to consider that sufficient material is measured to get a representative value.

Under the menu **"Calibration**" and the window "**Material Property Calibration**" the calibration curves CAL1 to Cal15 which are stored in the SONO probe are loaded and displayed on the screen (takes max. 1 minute). With the mouse pointer individual calibration curves can be tested with the SONO-probe by activating the button "**Set Active Calib**". The measurement of the moisture value (**MoistAve)** with the associated radar time **tpAve** at point P1 and P2 is started using the program SONO-CONFIG in the sub menu "**Test**" and "**Test in Mode CA or CF**" (see "Quick Guide for the Software SONO- CONFIG").

Step 1: The radar pulse time **tpAve** of the probe is measured with dried material. Ideally, this takes place during operation of a mixer/dryer in order to take into account possible density fluctuations of the material. It is recommended to detect multiple measurement values for finding a best average value for **tpAve**. The result is the first calibration point P1 (e.g. 70/0). I.e. 70ps (picoseconds) of the radar pulse time **tpAve** corresponds to 0% moisture content of the material. But it would be also possible to use a higher point P1´ (e.g. 190/7) where a **tpAve** of 190ps corresponds to a moisture content of 7%. The gravimetric moisture content of the material, e.g. 7% has to be determined with laboratory measurement methods (oven drying).

Step 2: The radar pulse time **tpAve** of the probe is measured with moist material. Ideally, this also takes place during operation of a mixer/dryer. Again, it is recommended to detect multiple measurement values of **tpAve** for finding a best average value. The result is the second calibration point P2 with X2/Y2 (e.g. 500/25). I.e. **tpAve** of 500ps corresponds to 25% moisture content. The gravimetric moisture content of the material, e.g. 25% has to be determined with laboratory measurement methods (oven drying).

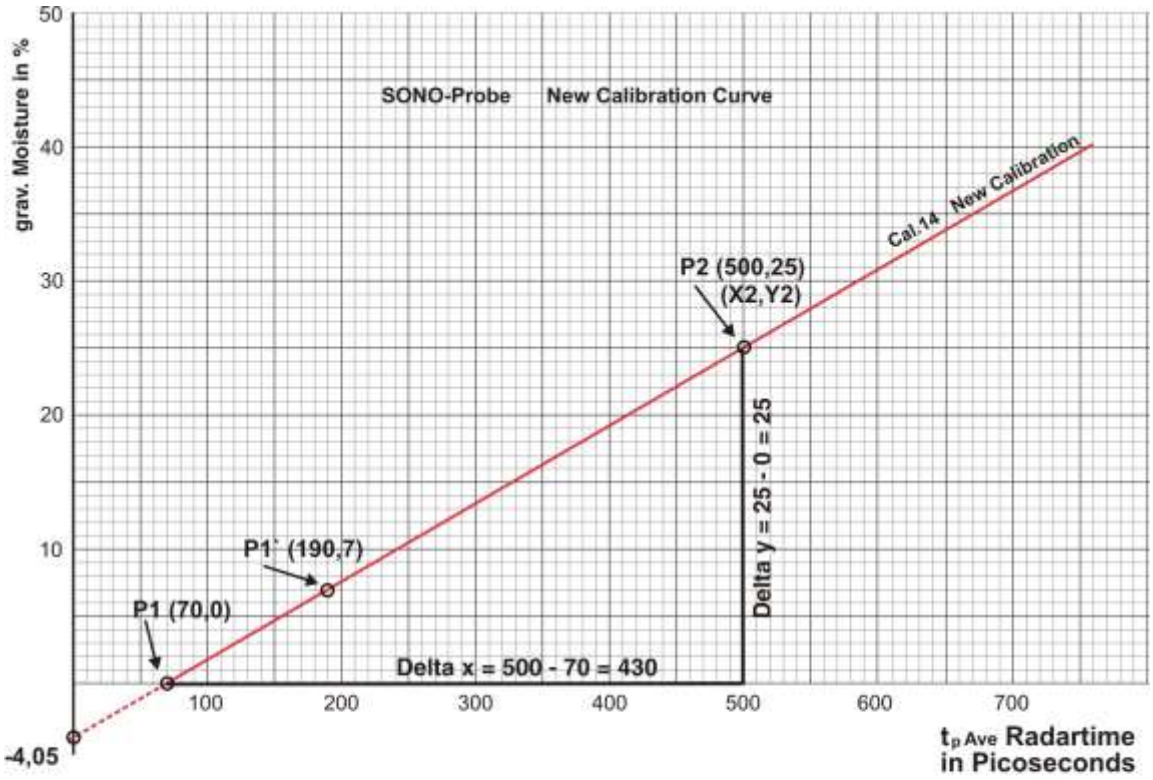
Step 3: With the two calibration points P1 and P2, the calibration coefficients m0 and m1 can be determined for the specific material (see next page). To calculate nonlinear coefficients for polynomials up to 5^{th} order, the software tool TRIME-WINCal of IMKO can be used (upon request).

Step 4: The coefficients m1 = 0.0581 and m0 = -4.05 (see next page) for the calibration curve Cal14 can be entered directly by hand and are stored in the probe by pressing the button "**Set**". The selected calibration curve (e.g. Cal14) which is activated after switching on the probes power supply will be adjusted with the button "**Set Default Calib**".

3.1.2. Nonlinear Calibration Curves

SONO probes can also work with non-linear calibration curves with polynomials up to 5th grade. Therefore it is necessary to calibrate with 4…8 different calibration points. To calculate nonlinear coefficients for polynomials up to 5th grade, an EXCEL software tool from IMKO can be used (on request). It is also possible to use any mathematical program like MATLAB for finding a best possible nonlinear calibration curve with suitable coefficient parameters m0 to m5.

The following diagram shows a sample calculation for a linear calibration curve with the coefficients m0 and m1 for a specific material.



The coefficient m_1 is calculated from the slope of the curve Cal14:

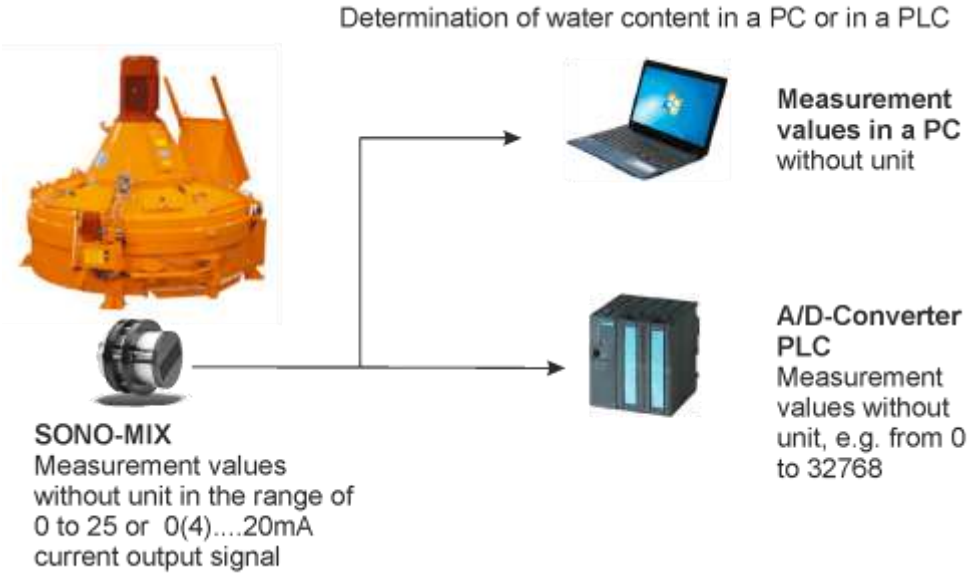
$$\text{Coefficient } m_1 = \frac{\text{Delta y}}{\text{Delta x}} = \frac{25 - 0}{500 - 70} = 0{,}0581$$

The coefficient m_0 is the offset on the y-axis at x = 0:

$$\text{Coefficient } m_0 = Y2 - (m_1 * X2) = 25 - (0{,}0581 * 500) = -4{,}05$$

3.2. How to perform a calibration with SONO-SILO or SONO-MIX for determination of water content, in 3 easy steps

The mixer probe SONO-SILO can measure water content precise, also in wet mixtures with higher cement contents. Therefore it opens up completely new possibilities for the calibration of the SONO-SILO in a mixer control system. In this example we show a new method where kiln drying of concrete samples is not necessary for a calibration of SONO-MIX. Furthermore the creation of different recipes should be easier.
The calculation of water content can be done with a PC or with a PLC. In the following example both options are shown, however only the PLC option is calculated with numbers (A/D-Converter PLC).


Determination of water content in a PC or in a PLC
Measurement values in a PC without unit
A/D-Converter PLC Measurement values without unit, e.g. from 0 to 32768
SONO-MIX Measurement values without unit in the range of 0 to 25 or 0(4)....20mA current output signal

Recommended way:

In this example the SONO-SILO has to be calibrated with a PLC for a concrete recipe with a specification of a setpoint wc-value of 0.385 (water/cement). With a binder content of 180kg the **setpoint for the water content** for the concrete results in **62.1 liter**.

1. Record measurement values in the PLC for the dry mixture, i.e. the mixture has a relative low water content. It is recommended to average the values of the PLC over the last 5 seconds of the dry mixing time. In this example a measurement value of 8126 has been recorded:

	SONO-SILO Measurement values (without unit from 4…20mA current output signal)	Measurement value in a PC (without unit)	**A/D-Converter PLC** (without unit from 0 to max. 32768)	Water content
Measurement values dry mixture	7.968 mA	6.2	8126 This is the **Dry-value-A/D**	? (not yet known)
Measurement values wet mixture				

2. Add water manually into the mixture, e.g. **38 liter mixing water.** Add manually as much water as the concrete recipe has the desired consistency. The added and measured water content is later used for the calculation of the c1-Sensitivity of the SONO-SILO for this recipe.
When the mixture has the optimal consistency, record the measurement values with the PLC in the wet mixture. It is recommended to average the values over the last 5 seconds of the wet mixing time. In this example a measurement value of 14811 has been recorded with the PLC.

	SONO-SILO Measurement values (without unit from 4…20mA current output signal)	Measurement value in a PC (without unit)	**A/D-Converter PLC** (without unit from 0 to max. 32768)	Water content
Measurement values dry mixture	7.968 mA	6.2	8126 This is the **Dry-value-A/D**	After completion of step 2. this value can be calculated in the following way: 62.1 l – 38 l = **24.1 l**
Measurement values wet mixture	11.232mA	11.3	14811 This is the **Target-value-A/D** for this concrete recipe for an optimal consistency of the recipe.	**62.1** (this water content value corresponds to the calculated w/c setpoint for the recipe at the beginning)

Note: For prefab concrete with higher flow spread, it is recommended to record the wet measurement values without concrete plasticizer in the mixture. The reason is that the plasticizer modifies the density of the fresh concrete considerably, which leads to deviations in the measurement values.

3. Determination of the sensitivity of the SONO-SILO for this recipe:
For calibration and calculation of the mixing water for further mixtures, the coefficient c1-Sensitivity of the SONO-SILO can be calculated easily in the following way:

c1-Sensitivity = (62.1 – 24.1) / (14811 – 8126) = **0.005685**

With help of the coefficient “c1-Sensitivity”, the amount of mixing water for future mixtures of this recipe can be calculated with the PLC after finishing of the dry mixing times:

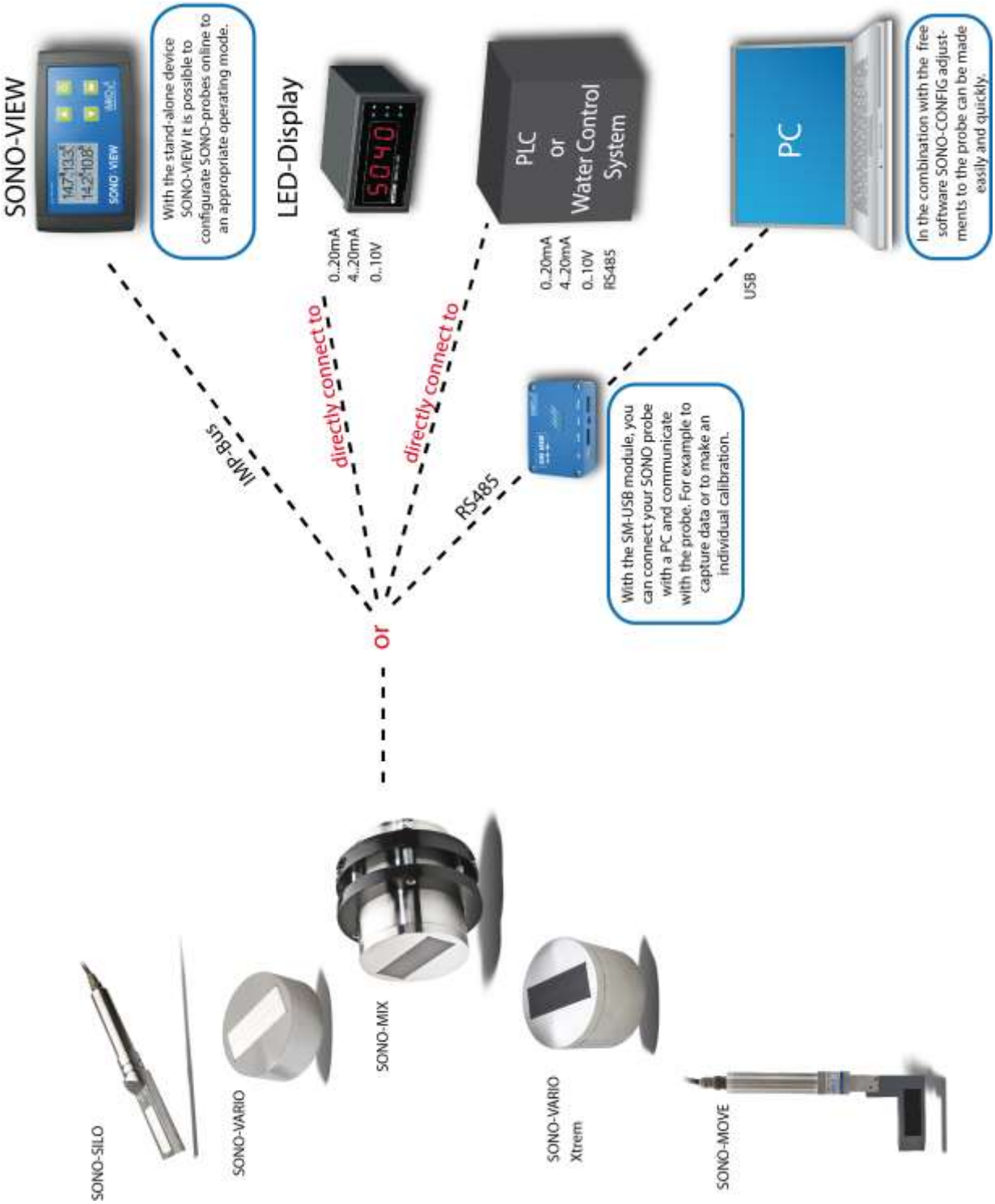
Mixing water = (Target-value-A/D – Dry-value-A/D) * c1 = (14811 – 8126) * 0.005685 = 38 Liter

Because the SONO-SILO measures moisture precise also with different grain size distribution, it is possible to calculate with a standard c1-Sensitivity for similar recipes. For very different recipes, e.g. recipes with colouring agents or other added special materials it is recommended to check the c1-Sensitivity and if necessary determine a new c1-Sensitivity.

For partial quantities you have only to multiply the calculated mixing water value with the partial percentage value, e.g. for an 80% partial quantity multiply 38 liter * 0.8 = 30.4 liter for the mixing water (subject to a correction for partial quantities).

The efforts and expenses for preparation additional parameters for different recipes inside a PLC should be easy and manageable when using this method.

4. Connectivity to SONO Probes



4.1.1. Connection Plug

SONO-SILO is supplied with a 10-pole MIL flange plug.

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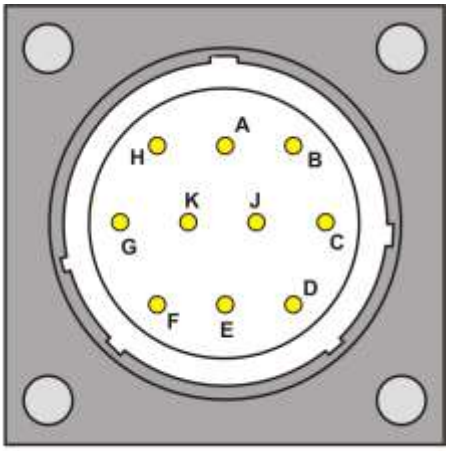
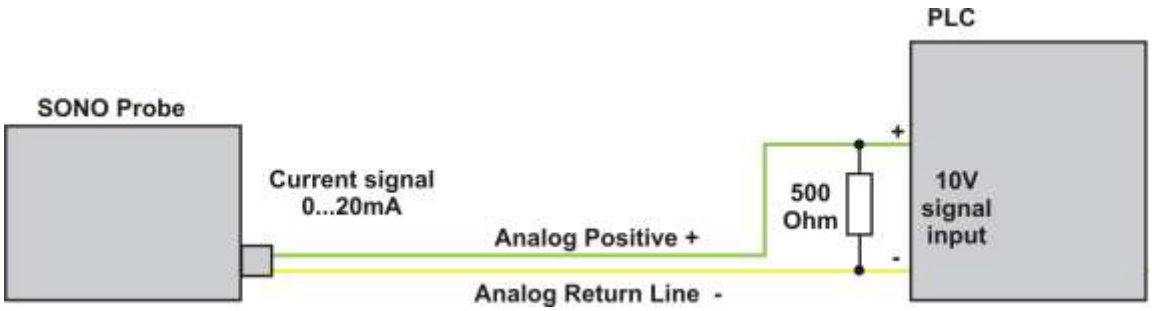


Assignment of the 10-pole MIL plug and sensor cable connections:

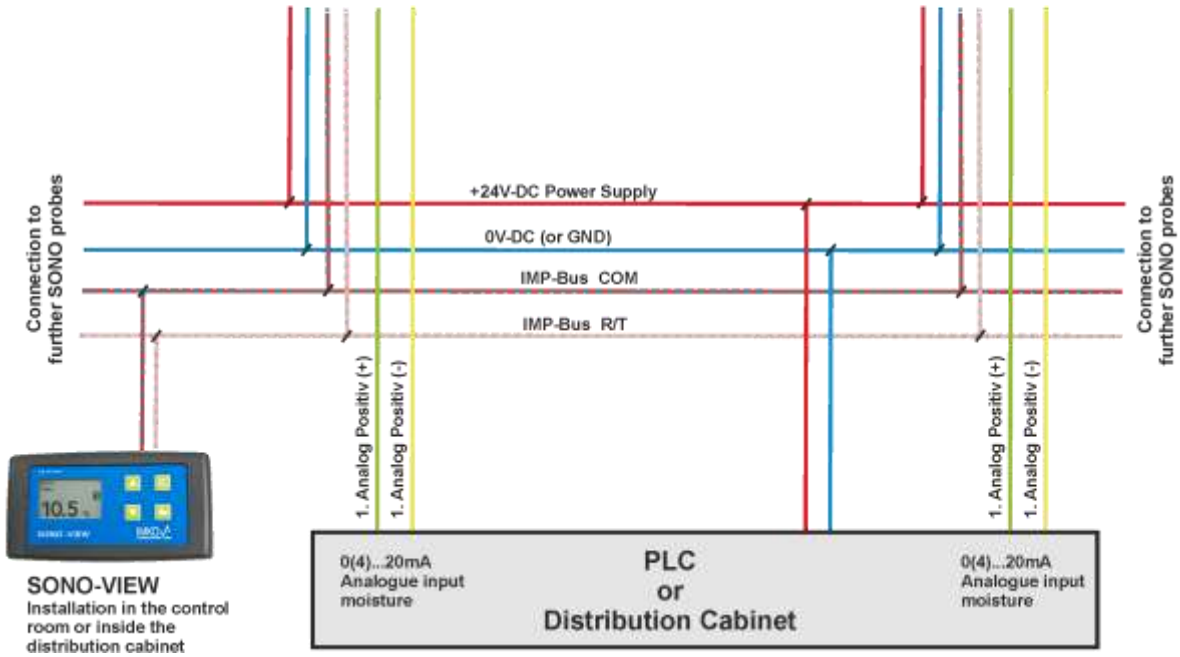
Plug-PIN	Sensor Connections	Lead Colour	Lead Colour
A	+7V….24V Power Supply	red	red
B	0V Power Supply	Blue	Blue
D	1. Analogue Positive (+) Moisture	Green	Green
E	1. Analogue Return Line (-) Moisture	yellow	yellow
F	RS485 A	white	white
G	RS485 B	brown	brown
C	(rt) IMP-Bus	grey/pink	grey/pink
J	(com) IMP-Bus	blue/red	blue/red
K	2. Analogue Positive (+)	Pink	Pink
E	2. Analogue Return Line (-)	Grey	Grey
H	Screen (is grounded at the sensor. The plant must be properly grounded!)	transparent	transparent

4.1.2. Analogue Output 0..10V with a Shunt-Resistor

There are PLC´s which have no current inputs 0..20mA, but voltage inputs 0..10V. With the help of a shunt resistor with 500 ohm (in the delivery included) it is possible to generate a 0..10V signal from the current signal 0..20mA. The 500 ohm shunt resistor should be placed at the end of the line resp. at the input of the PLC. Following drawing shows the circuit principle.

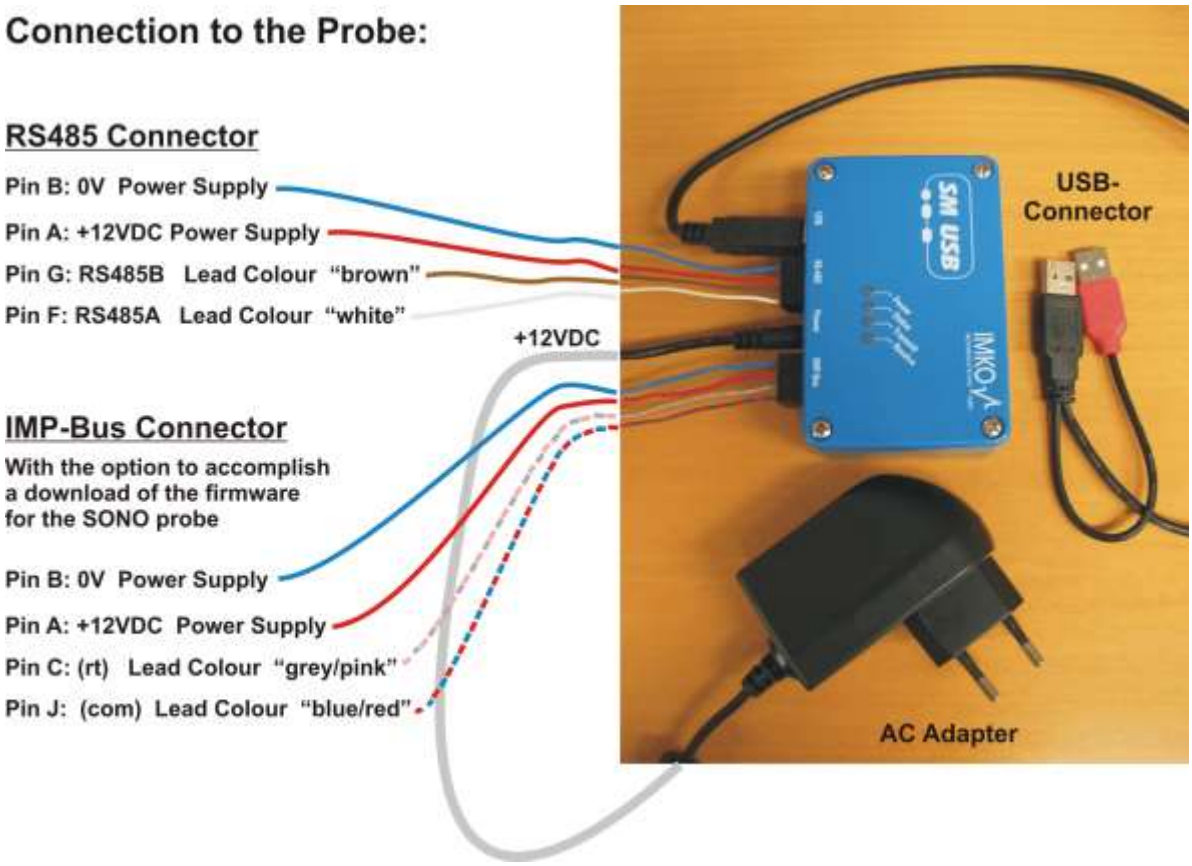


4.1.3. Connection diagramm with SONO-VIEW



4.2. Connection of the RS485 to the SM-USB Module from IMKO

The SM-USB provides the ability to connect a SONO probe either to the standard RS485 interface or to the IMP-Bus from IMKO. **In fact that the IMP-Bus is more robust and enables the download of a new firmware to the SONO probe, the SONO probes are presetted ex-factory to the IMP-Bus. So it is recommended to use the IMP-Bus for a serial communication**. Both connector ports are shown in the drawing below.
The SM-USB is signalling the status of power supply and the transmission signals with 4 LED´s. When using a dual-USB connector on the PC, it is possible to use the power supply for the SONO probe directly from the USB port of the PC without the use of the external AC adapter.



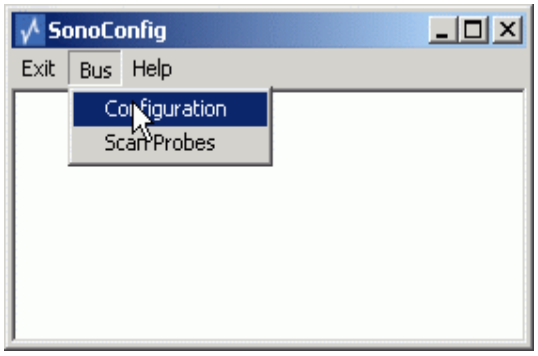
How to start with the USB-Module SM-USB from IMKO

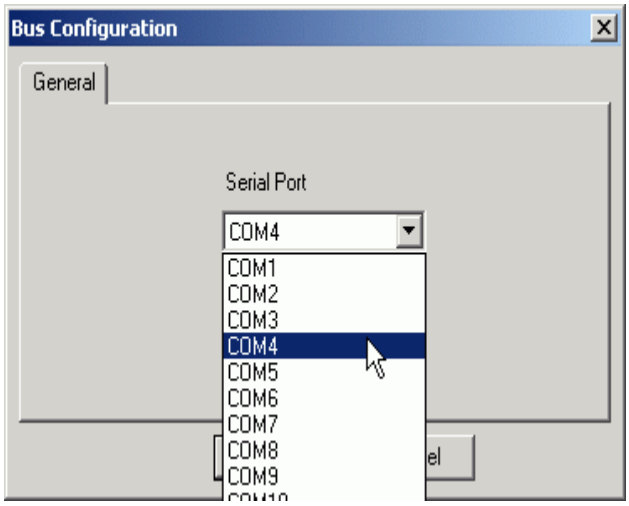
- Install USB-Driver from USB-Stick.
- Connect the SM-USB to the USB-Port of the PC and the installation will be accomplished automatically.
- Install Software **SONOConfig-SetUp.msi** from USB-Stick.
- Connection of the SONO probe to the EX9531 via RS485A, RS485B and 0V.
- Check the setting of the COM-Ports in the Device-Manager und setup the specific COM-Port with the Baudrate of 9600 Baud in SONO-CONFIG with the button "**Bus**" and "**Configuration**" (COM1-COM15 is possible).
- Start "**Scan probes**" in SONOConfig.
- The SONO probe logs in the window „**Probe List**" after max. 30 seconds with its serial number.

5. Quick Guide for the Commissioning Software SONO-CONFIG

With SONO-CONFIG it is possible to make process-related adjustments of individual parameters of the SONO probe. Furthermore the measurement values of the SONO probe can be read from the probe via the serial interface and displayed on the screen.

In the menu **"Bus**" and the window "**Configuration**" the PC can be configured to an available COMx-port with the Baudrate of 9600 Baud.

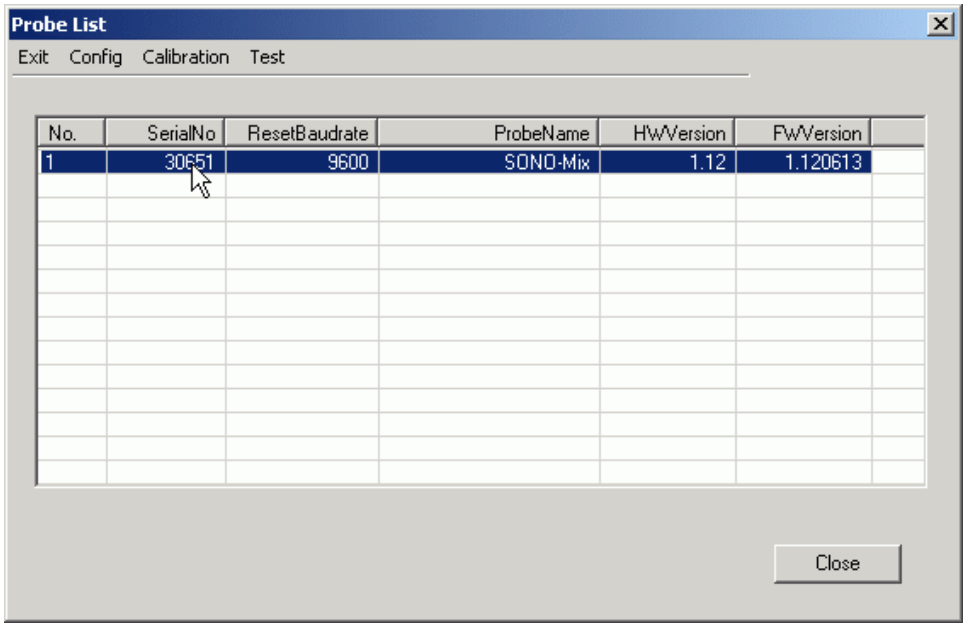




5.1.1. Scan of connected SONO probes on the serial interface

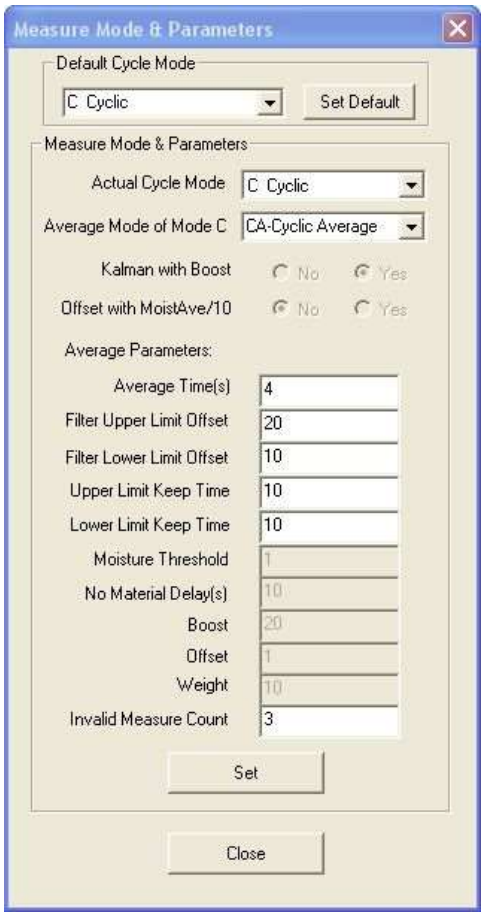
In the menu **"Bus**" and the window "**Scan Probes**" the serial bus can be scanned for attached SONO probes (takes max. 30 seconds).

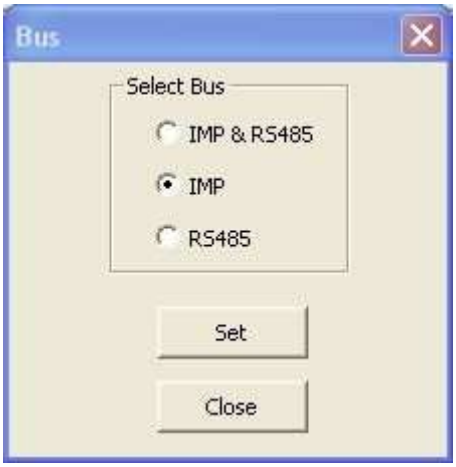
SONO-CONFIG reports one or more connected and founded SONO probes with its serial number in the window "**Probe List**". One SONO probe can be selected by klicking.



5.1.2. Configuration of Measure Mode and serial SONO-interface

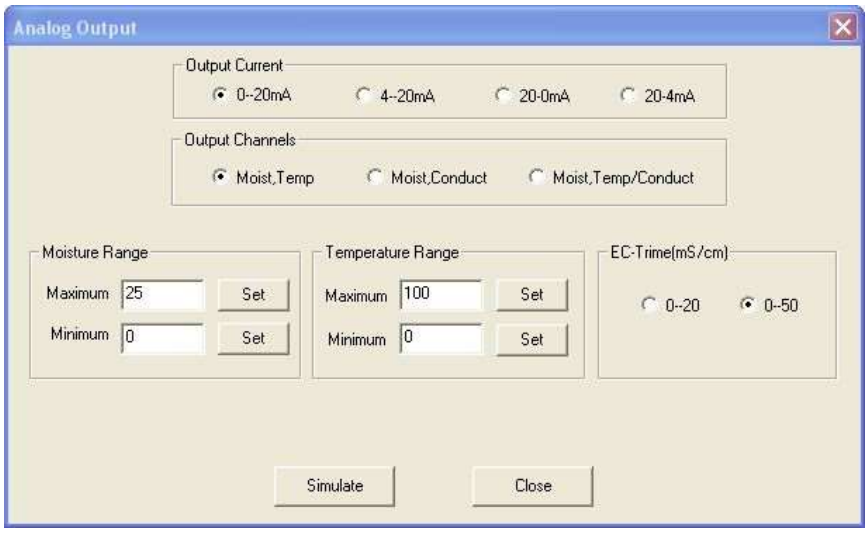
In "**Probe List**" with "**Config**" and "**Measure Mode & Parameters**" the SONO probe can be adjusted to the desired measure mode CA, CF, CS, CK, CC or CH (see Chapter "Configuration Measure Mode"). Furthermore the serial interface inside the SONO probe can be selected to IMP-Bus, RS485 or both interfaces. Due to very robust behavior it is recommended to select the IMP-Bus.





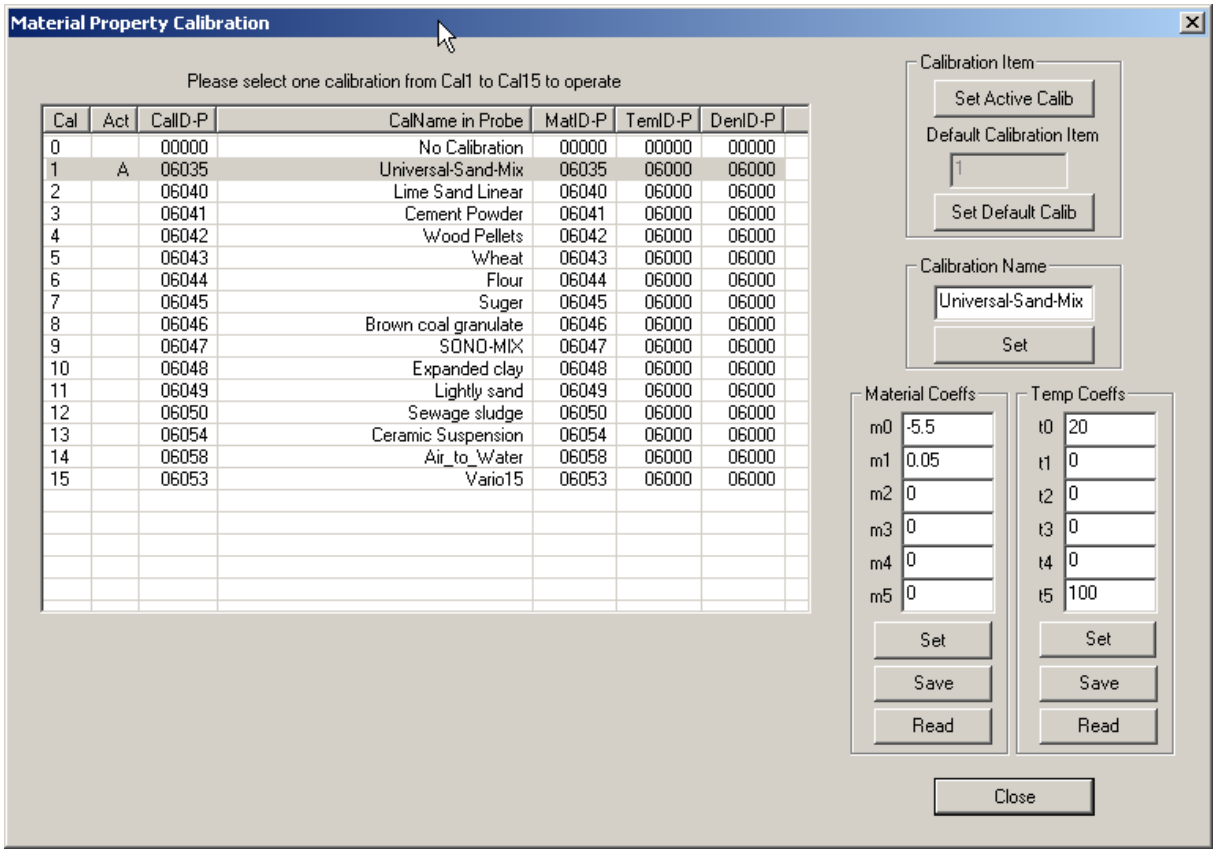
5.1.3. Analogue outputs of the SONO probe

In the menu "**Config**" and the window "**Analog Output**" the analogue outputs of the SONO probe can be configured (see Chapter "Analogue outputs..").



5.1.4. Selection of the individual Calibration Curves

In the menu **"Calibration**" and the window "**Material Property Calibration**" the calibration curves CAL1 to Cal15 which are stored in the SONO probe are loaded and displayed on the screen (takes max. 1 minute). With the mouse pointer individual calibration curves can be activated and tested with the SONO-probe by activating the button "**Set Active Calib**". Furthermore, the individual calibration curves CAL1 to Cal15 can be adapted or modified with the calibration coefficients (see Chapter “Creating a linear calibration curve”).


Material Property Calibration
Please select one calibration from Cal1 to Cal15 to operate
Cal | Act | CalID-P | CalName in Probe | MatID-P | TemID-P | DenID-P
0 | | 00000 | No Calibration | 00000 | 00000 | 00000
1 | A | 06035 | Universal-Sand-Mix | 06035 | 06000 | 06000
2 | | 06040 | Lime Sand Linear | 06040 | 06000 | 06000
3 | | 06041 | Cement Powder | 06041 | 06000 | 06000
4 | | 06042 | Wood Pellets | 06042 | 06000 | 06000
5 | | 06043 | Wheat | 06043 | 06000 | 06000
6 | | 06044 | Flour | 06044 | 06000 | 06000
7 | | 06045 | Suger | 06045 | 06000 | 06000
8 | | 06046 | Brown coal granulate | 06046 | 06000 | 06000
9 | | 06047 | SONO-MIX | 06047 | 06000 | 06000
10 | | 06048 | Expanded clay | 06048 | 06000 | 06000
11 | | 06049 | Lightly sand | 06049 | 06000 | 06000
12 | | 06050 | Sewage sludge | 06050 | 06000 | 06000
13 | | 06054 | Ceramic Suspension | 06054 | 06000 | 06000
14 | | 06058 | Air_to_Water | 06058 | 06000 | 06000
15 | | 06053 | Vario15 | 06053 | 06000 | 06000
Calibration Item
Set Active Calib
Default Calibration Item
1
Set Default Calib
Calibration Name
Universal-Sand-Mix
Set
Material Coeffs
m0 -5.5
m1 0.05
m2 0
m3 0
m4 0
m5 0
Set
Save
Read
Temp Coeffs
t0 20
t1 0
t2 0
t3 0
t4 0
t5 100
Set
Save
Read
Close

The desired and possibly altered calibration curve (Cal1. .15) which is activated after switching on the probes power supply can be adjusted with the button "**Set Default Calib**”.

The calibration name can be entered in the window “Calibration Name”.

The coefficients m0 to m1 (for linear curves) and m0 to m5 (for non-linear curves) can be entered and adjusted directly by hand with the buttons “**Set**” and “**Save**”.

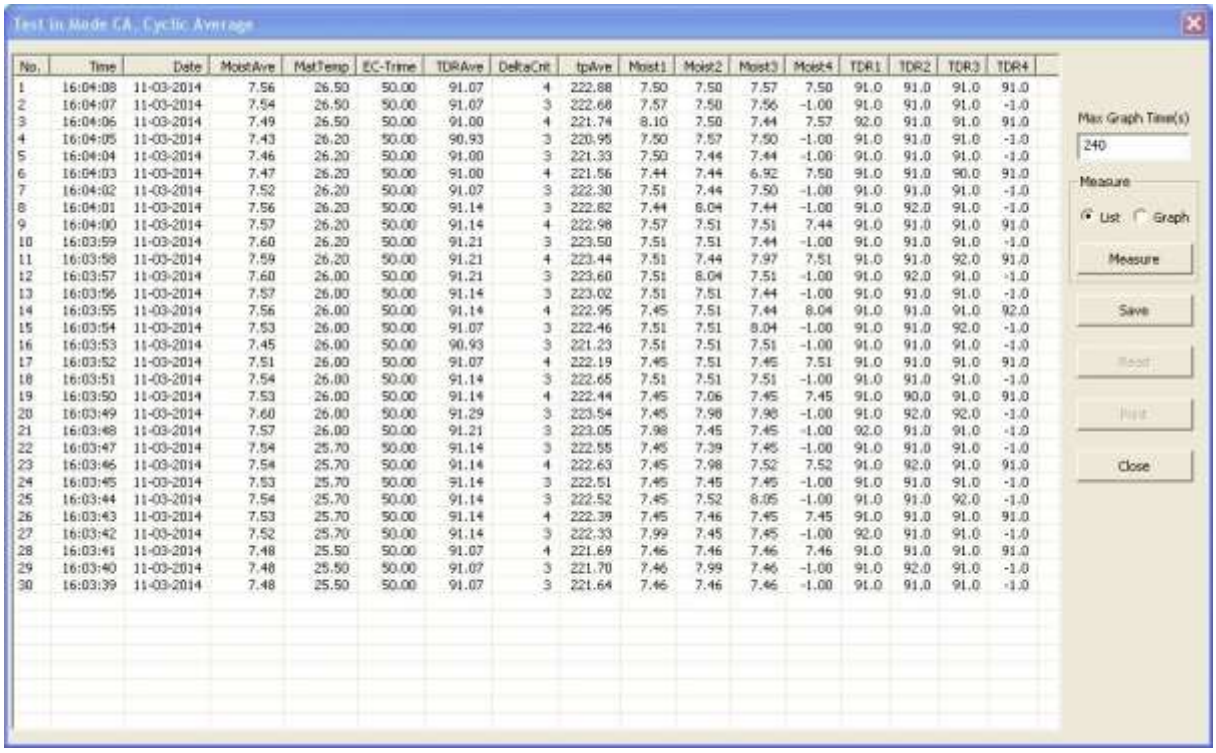
Possible are non-linear calibration curves with polynomials up to fifth order (m0-m5).

Attention: Use “dot” as separator for m0 to m5 not comma !

5.1.5. “Test” run in the respective Measurement Mode

In the menu "**Test**" and the window "**Test in Mode CA or CF**" the measured moisture values **“MoistAve”** (Average) of the SONO probe are displayed on the screen and can be parallel saved in a file. In the menu "**Test**" and the window "**Test in Mode CS**" the measured single measurement values “**Moist**” (5 values per second) of the SONO probe are displayed on the screen and parallel stored in a file. In „**Test in Mode A“** single measurement values (without average) are displayed on the screen and can also be stored in a file.

Attention: for a test run in mode CA, CF, CS or A it must be ensured that the SONO probe was also set to this mode (Measure Mode CA, CF, CS, A). If this is not assured, the probe returns zero values.



No.	Time	Date	MoistAve	MatTemp	EC-Trime	TDRAve	DeltaCnt	tpAve	Moist1	Moist2	Moist3	Moist4	TDR1	TDR2	TDR3	TDR4
1	16:04:08	11-03-2014	7.56	26.50	50.00	91.07	4	222.88	7.50	7.50	7.57	7.50	91.0	91.0	91.0	91.0
2	16:04:07	11-03-2014	7.54	26.50	50.00	91.07	3	222.68	7.57	7.50	7.56	-1.00	91.0	91.0	91.0	-1.0
3	16:04:06	11-03-2014	7.49	26.50	50.00	91.00	4	221.74	8.10	7.50	7.44	7.57	92.0	91.0	91.0	91.0
4	16:04:05	11-03-2014	7.43	26.20	50.00	90.93	3	220.95	7.50	7.57	7.50	-1.00	91.0	91.0	91.0	-1.0
5	16:04:04	11-03-2014	7.46	26.20	50.00	91.00	3	221.33	7.50	7.44	7.44	-1.00	91.0	91.0	91.0	-1.0
6	16:04:03	11-03-2014	7.47	26.20	50.00	91.00	4	221.56	7.44	7.44	6.92	7.50	91.0	91.0	90.0	91.0
7	16:04:02	11-03-2014	7.52	26.20	50.00	91.07	3	222.30	7.51	7.44	7.50	-1.00	91.0	91.0	91.0	-1.0
8	16:04:01	11-03-2014	7.56	26.20	50.00	91.14	3	222.82	7.44	8.04	7.44	-1.00	91.0	92.0	91.0	-1.0
9	16:04:00	11-03-2014	7.57	26.20	50.00	91.14	4	222.98	7.57	7.51	7.51	7.44	91.0	91.0	91.0	91.0
10	16:03:59	11-03-2014	7.60	26.20	50.00	91.21	3	223.50	7.51	7.51	7.44	-1.00	91.0	91.0	91.0	-1.0
11	16:03:58	11-03-2014	7.59	26.20	50.00	91.21	4	223.44	7.51	7.44	7.97	7.51	91.0	91.0	92.0	91.0
12	16:03:57	11-03-2014	7.60	26.00	50.00	91.21	3	223.60	7.51	8.04	7.51	-1.00	91.0	92.0	91.0	-1.0
13	16:03:56	11-03-2014	7.57	26.00	50.00	91.14	3	223.02	7.51	7.51	7.44	-1.00	91.0	91.0	91.0	-1.0
14	16:03:55	11-03-2014	7.56	26.00	50.00	91.14	4	222.95	7.45	7.51	7.44	8.04	91.0	91.0	91.0	92.0
15	16:03:54	11-03-2014	7.53	26.00	50.00	91.07	3	222.46	7.51	7.51	8.04	-1.00	91.0	91.0	92.0	-1.0
16	16:03:53	11-03-2014	7.45	26.00	50.00	90.93	3	221.23	7.51	7.51	7.51	-1.00	91.0	91.0	91.0	-1.0
17	16:03:52	11-03-2014	7.51	26.00	50.00	91.07	4	222.19	7.45	7.51	7.45	7.51	91.0	91.0	91.0	91.0
18	16:03:51	11-03-2014	7.54	26.00	50.00	91.14	3	222.65	7.51	7.51	7.51	-1.00	91.0	91.0	91.0	-1.0
19	16:03:50	11-03-2014	7.53	26.00	50.00	91.14	4	222.44	7.45	7.06	7.45	7.45	91.0	90.0	91.0	91.0
20	16:03:49	11-03-2014	7.60	26.00	50.00	91.29	3	223.54	7.45	7.98	7.98	-1.00	91.0	92.0	92.0	-1.0
21	16:03:48	11-03-2014	7.57	26.00	50.00	91.21	3	223.05	7.98	7.45	7.45	-1.00	92.0	91.0	91.0	-1.0
22	16:03:47	11-03-2014	7.54	25.70	50.00	91.14	3	222.55	7.45	7.39	7.45	-1.00	91.0	91.0	91.0	-1.0
23	16:03:46	11-03-2014	7.54	25.70	50.00	91.14	4	222.63	7.45	7.98	7.52	7.52	91.0	92.0	91.0	91.0
24	16:03:45	11-03-2014	7.53	25.70	50.00	91.14	3	222.51	7.45	7.45	7.45	-1.00	91.0	91.0	91.0	-1.0
25	16:03:44	11-03-2014	7.54	25.70	50.00	91.14	3	222.52	7.45	7.52	8.05	-1.00	91.0	91.0	92.0	-1.0
26	16:03:43	11-03-2014	7.53	25.70	50.00	91.14	4	222.39	7.45	7.46	7.45	7.45	91.0	91.0	91.0	91.0
27	16:03:42	11-03-2014	7.52	25.70	50.00	91.14	3	222.33	7.99	7.45	7.45	-1.00	92.0	91.0	91.0	-1.0
28	16:03:41	11-03-2014	7.48	25.50	50.00	91.07	4	221.69	7.46	7.46	7.46	7.46	91.0	91.0	91.0	91.0
29	16:03:40	11-03-2014	7.48	25.50	50.00	91.07	3	221.70	7.46	7.99	7.46	-1.00	91.0	92.0	91.0	-1.0
30	16:03:39	11-03-2014	7.48	25.50	50.00	91.07	3	221.64	7.46	7.46	7.46	-1.00	91.0	91.0	91.0	-1.0

Following measurement values are displayed on the screen:

MoistAve	Moisture Value in % (Average)
MatTemp	Temperature
EC-TRIME	Radar-based-Conductivity EC-TRIME in dS/m (or mS/cm)
TDRAve	TDR-Signal-Level for special applications.
DeltaCount	Number of single measurements which are used for the averaging.
tpAve	Radar time (average) which corresponds to the respective moisture value.

By clicking „**Save**“ the recorded data is saved in a text file in the following path:
\SONO-CONFIG.exe-Pfad\MD\Dateiname

The name of the text file **Statis+SN+yyyymmddHHMMSS.sts** is assigned automatically with the serial number of the probe (SN) and date and time. The data in the text file can be evaluated with Windows-EXCEL.

5.1.6. “Measure” run in Datalogger-Operation

In the menu **"Measure"** it is possible to aquire and store measurement data from several SONO probes with variable and longer cycle rates in a datalogger-operation, e.g. to store measurement data during a long-term drying cycle.

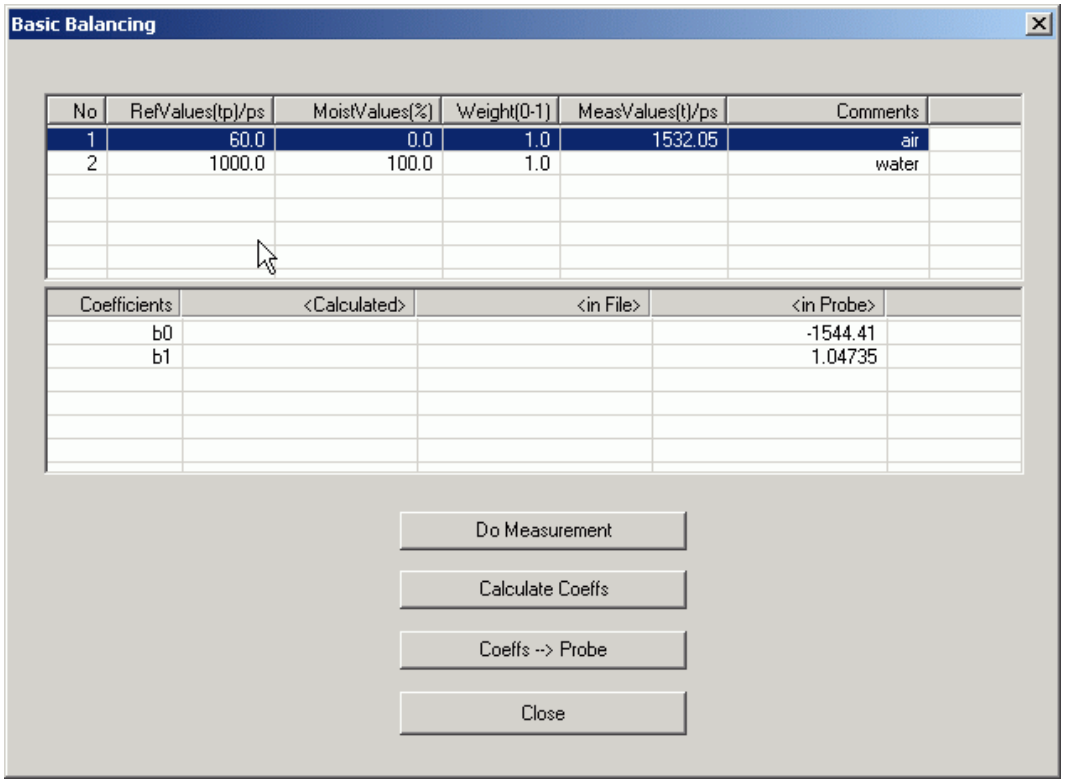
5.1.7. Basic Balancing in Air and Water

SONO probe heads are identical and manufactured precisely. After an exchange of a probe head it is nevertheless advisable to verify the calibration and to check the basic calibration and if necessary to correct it with a “Basic Balancing”.
With a “Basic Balancing” two reference calibration measurements are to be carried out with known set-points ("RefValues"). For the reference media, different calibration materials are used, dependent on the SONO probe type. For SONO probes with a ceramic measurement window, air and water (tap water) is used. For other SONO probes like SONO-GS1 glass beads are used for basic calibrations (on request).

Attention: Before performing a “Basic Balancing” it must be ensured that the SONO probe was set to “Measure Mode” A. If this is not assured, the probe returns zero values. After a “Basic Balancing” the SONO probe has to be set to “Measure Mode C” again, because otherwise the probe would not measure continuously!

In the menu **"Calibration**" and the window "**Basic Balancing**" the two set-point values of the radar time **tp** are displayed with 60ps and 1000ps.

1. Reference set-point A: **tp**=60ps in air (the surface of the probe head must be dry!!)
   The first set-point can be activated with the mouse pointer by clicking to No.1. By activating the button "**Do Measurement**" the SONO probe determines the first reference set-point in air. In the column „MeasValues“ the measured raw value of the radar time **t** is displayed (e.g. 1532.05 picoseconds).
2. Reference set-point B: **tp**=1000ps in water. The SONO probe head has to be covered with water in a height of about 50mm. The second set-point can be activated with the mouse pointer by clicking to No.2. By activating the button "**Do Measurement**" the SONO probe determines the second reference set-point in water. In the column „MeasValues“ the measured raw value of the radar time **t** is displayed.
3. By activating the button „**Calculate Coeffs**“ and „**Coeffs → Probe**“ the alignment data is calculated automatically and is stored in the SONO probe non-volatile. With a “Test run” (in Mode A) the radar time **tp** of the SONO probe should be now 60ps in air and 1000ps in water.



6. Installation of the Probe

The installation conditions are strongly influenced by the constructional circumstances of the installation facility. The ideal installation location must be established individually. The following guidelines should hereby be observed.

The probe can be fitted with a pipe extension with 55mm outer diameter in silos. The length of the extension tube is dependent on the particular facility and must be adjusted by the customer. For easy mounting a mounting flange with 55mm inner diameter is deliverable The ability to incline the sensor surface allows the setting of minimum density fluctuations.
It is important that the probe is positioned in an optimal material flow. For larger particle sizes the use of a deflector plate is required.

6.1. Assembly Instructions

Unfavourable conditions for moisture probes can occur if the sand is very sticky and the probes are installed inside silos or inside outlets.

The picture shows how sticky and adhere sand can be, even at near-vertical walls. Furthermore a moisture probe can be seen which is installed directly inside the outlet of a silo, where sand can stick not only at the wall but also on the moisture probe. Such an installation place can lead to measurement failures if sand is very sticky!

The following instructions should be followed when installing the probe:

- The installation locations may not be situated beneath the inlets for additives.
- Areas with strong turbulences are not ideal for the installation. There should be a continuous material flow above the probe head.
- The probe should not be installed in the direct vicinity of electrical disturbing sources such as motors.
- **An ideally installation place for moisture probes is directly under a silo flap, because this leads to obvious advantage.**

Attention! Risk of Breakage!

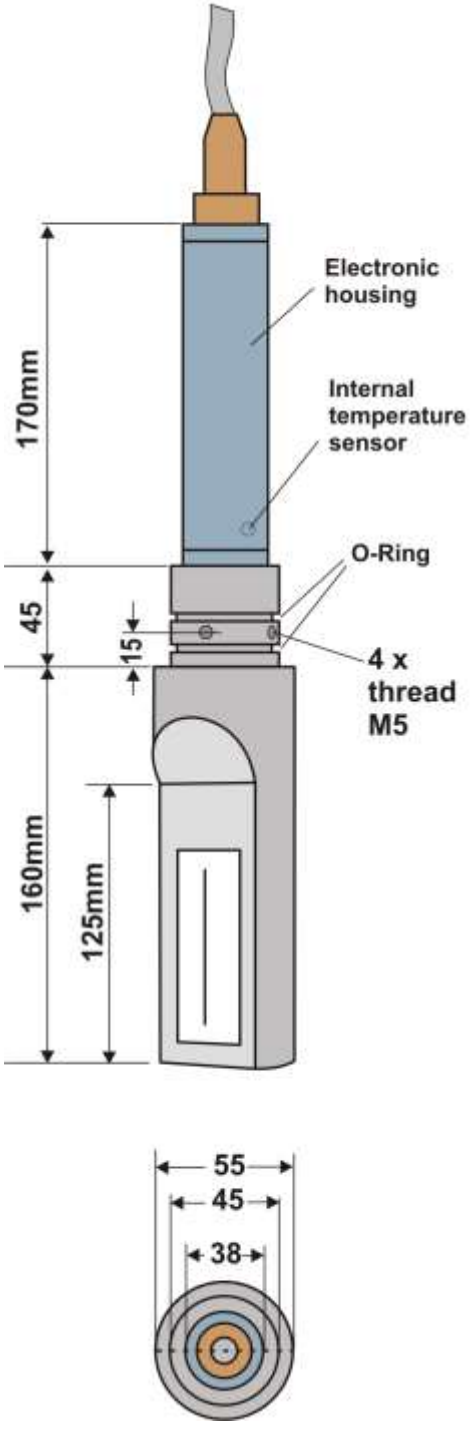
The probe head is made of hardened special steel and a very wear-resistant ceramic in order to warrant for a long life-span of the probe. In spite of the robust and wear-resistant construction, the ceramic plate may not be exposed to any blows as ceramic is prone to breakage.

In case of welding work at the plant, all probes must be completely electrically disconnected.

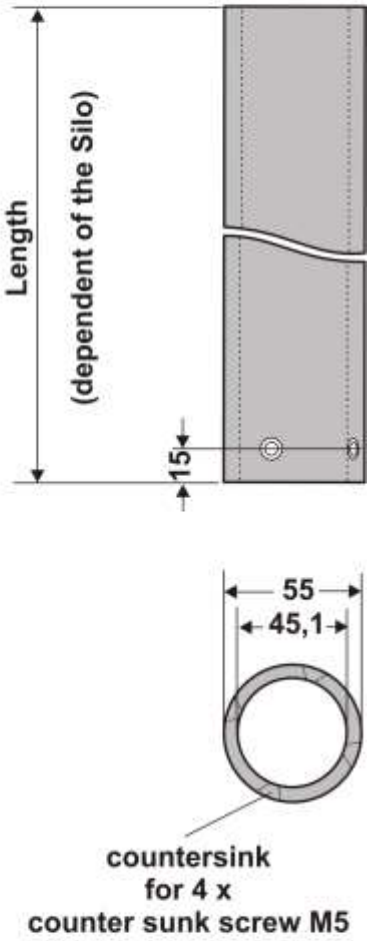
Any damage caused by faulty installation is not covered by the warranty!

Abrasive wear of sensor parts is not covered by the warranty!

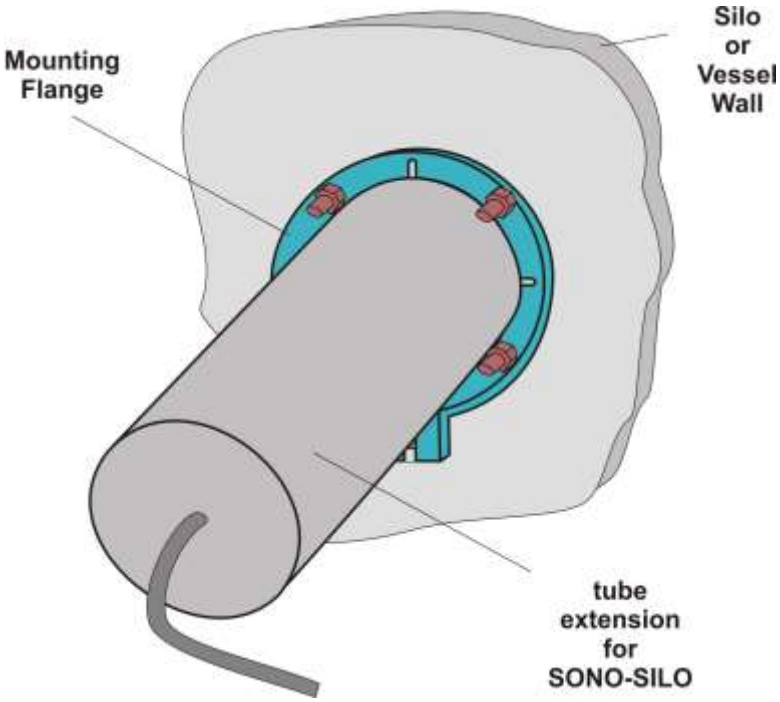
6.2. Dimensions SONO-SILOStandard and SONO-SILOXtrem



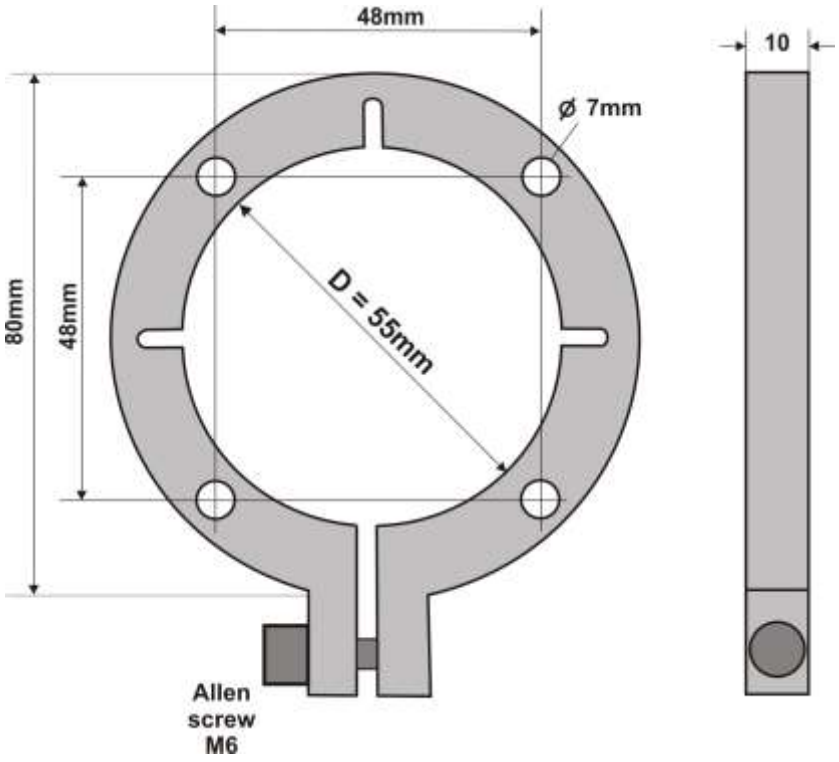
Tube Extension (steel) for SONO-SILOStandard



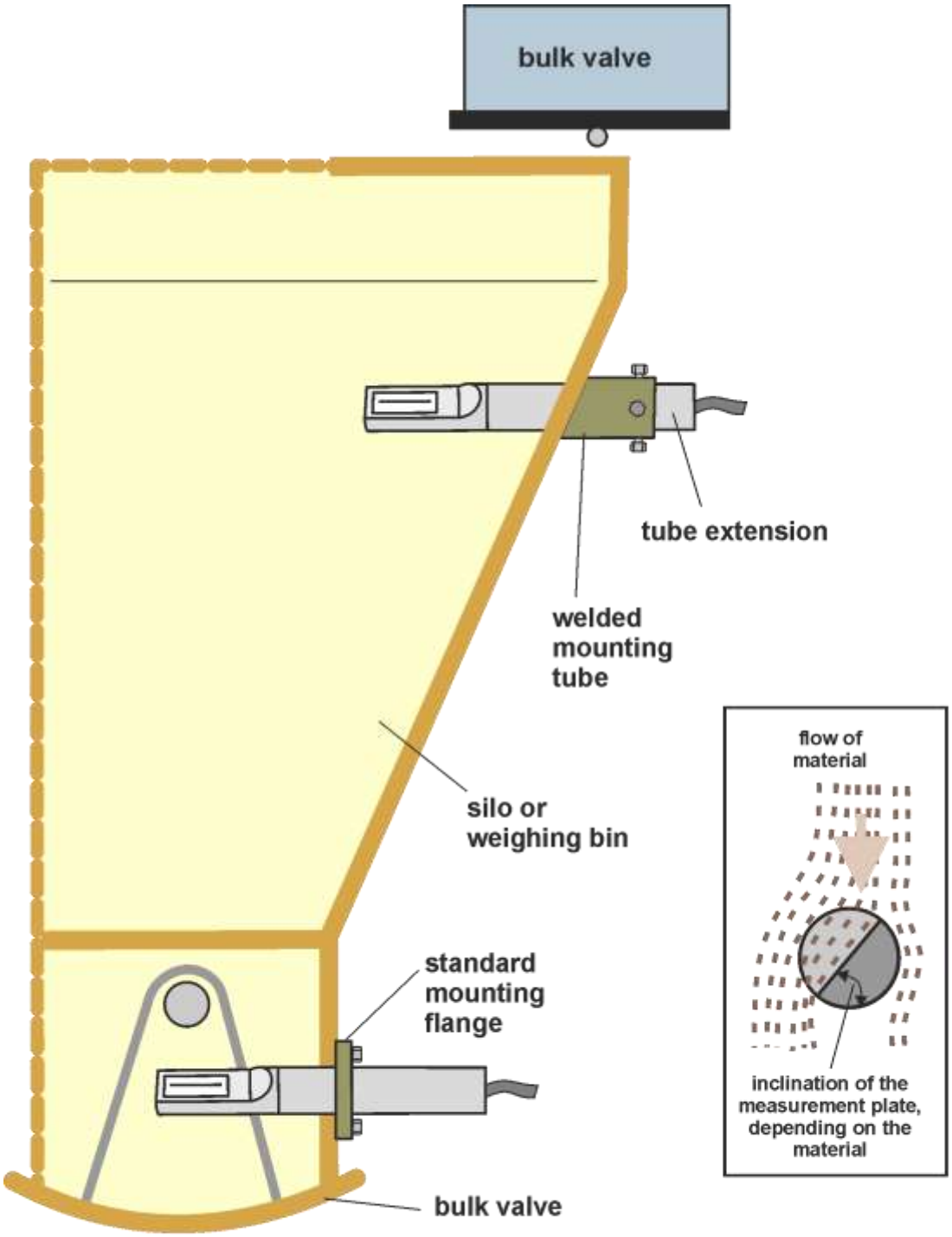
6.3. Mounting of SONO-SILO

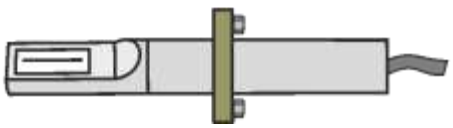


Dimensions of the Mounting Flange



6.4. Mounting on a silo or weighing bin





An ideally installation place for the SONO-SILO is directly under a silo flap: Best conditions for non-sticking of material and a visually control.

6.5. Gas- and waterproofed Installation

For a gas- and waterproofed installation up to 10bar pressure and a temperature range of -40°C to +100°C a special tube fitting for a diameter of 55mm is deliverable (on request).

7. Technical Data SONO-SILO

SENSOR DESIGN

SONO-SILO$_{Standard}$:
Casing Electronic Head: High Grade Steel V2A 1.4301
Casing Probe: High Grade Steel V2A 1.4301
Abrasion Surface: Highly abrasion-resistant aluminium oxide ceramic.
SONO-SILO$_{Xtrem}$:
Casing Electronic Head: High Grade Steel V2A 1.4301
Casing Probe: High Grade Steel V2A 1.4301
Abrasion Surface: Highly abrasion-resistant Si3O4 oxide ceramic.

MOUNTING

Sensor Dimensions: 55 x 350mm (Diameter x Length)

The sensor can be installed into silos with tube extensions. The length of the tube extension is dependent on the installation facility. The mounting flange can be screwed on to the rear side of any silo, container or hopper.
A gas- and waterproofed tube fitting is available on request!

MEASUREMENT RANGE MOISTURE

The sensor measures from 0% up to the point of material saturation.
Measurement ranges up to 90% moisture are possible with a special calibration.

MEASUREMENT RANGE CONDUCTIVITY

The sensor, as a material-specific characteristic value, delivers the radar-based conductance (RbC – **R**adar-**b**ased-**C**onductance). The conductivity range is reduced in moisture measurement ranges >50%.

SONO-SILO$_{Standard}$: 0..12dS/m conductivity
SONO-SILO$_{Xtrem}$: 0...40dS/m conductivity

MEASUREMENT RANGE TEMPERATURE

Measurement Range: 0°C …70°C
A temperature sensor is installed into the SONO-SILO´s electronic housing which establishes the casing temperature beneath the probe head (see point 3.2). The temperature can optionally be issued at the analogue output 2. As the TRIME electronics operates with a power of approximately 1.5 W, the probe casing does slightly heat up. A very precise measurement of the material temperature is therefore only possible to a certain degree and only if the electronic housing is completely surrounded by the material. The material temperature can be determined after an external calibration and compensation of the sensor self-heating.

On request: High temperature version with external measurement transformer

MEASUREMENT DATA-PREPROCESSING

MEASUREMENT MODE CA: (Cyclic-Average) For relative short measuring processes with continual average value, filtering and an accuracy of up to 0.1%
MEASUREMENT CF: (Cyclic-Float-Average) For very slow measuring processes with floating average value, filtering and an accuracy of up to 0.1%
MEASUREMENT MODE CS: (Cyclic-Successive) For very short measuring processes without floating average with internal up to 100 measurements per second and a cycle time of 200 milliseconds at the analogue output.
Mode CC: (Cyclic Cumulated) with automatic summation of a moisture quantity during one batch process.
Mode CH: (Cyclic Hold) similar to Mode CC but without summation.

SIGNAL OUTPUT

2 x Analogue Outputs 0(4)…20mA
Output 1: Moisture in % (0..20% variably adjustable)
Output 2: Conductivity (RbC) 0..20dS/m, or optionally the temperature.
In addition, there is the option to split the analogue output 2 into two ranges: into 4..11mA for the temperature and 12..20mA for the conductivity. The analogue output 2 hereby changes over into an adjustable 5 second cycle between these two (current) measurement windows.

The two analogue outputs can be variably aligned with the SONO-CONFIG software. For a 0-10V DC voltage output, a 500R resistor can be installed.

CALIBRATION

The sensor is provided with a universal calibration for sand. A maximum of 15 different calibrations can be stored. For special materials, variable calibrations with polynomials up to the 5^{th} order are possible and can be downloaded into the sensor with the SONO-CONFIG software (Download per Internet). A zero point correction can be performed easily with the SONO-CONFIG software.

COMMUNICATION

A RS485 interface enables network operation of the sensor, whereby a data bus protocol for the connection of several SONO sensors to the RS485 is implemented by default. The connection of the sensor to industrial busses such as Profibus, Ethernet, etc. is possible via optional external modules (available upon request).

POWER SUPPLY

+7V to +24V DC, 1.5 W max.

AMBIENT CONDITIONS

0 - 70°C
On request: High temperature version with external measurement transformer

MEASUREMENT FIELD EXPANSION

Approximately 50 - 80 mm, depending on material and moisture.

CONNECTOR PLUG

The sensor is equipped with a robust 10-pole MIL flange connector. Ready made connection cables with MIL connectors are available in the lengths 4m, 10m, or 25m.

Precise Moisture Measurement

in industry, hydrology, forestry, agriculture, environmental and earth science, civil engineering, as well as individual applications!